

WIRED

UK EDITION

INSIDE

JUL 15
WIRED.CO.UK

Google's SECRET ARTIFICIAL INTELLIGENCE PROJECT

DEEPMIND, LONDON'S MOST
AMBITIOUS STARTUP, IS BUILDING
MACHINES THAT THINK.

There's a lot of misun-
derstanding about artificial
intelligence. It's not just
about who are smart
machines but don't work
like humans. It's about
needing artificial
intelligence to make the breakth-
roughs we want. Climate
change – they're just tr
complicated interacti
barrier for humans
to handle that data and make
sense of it. We might have
the possibility that th
that human exper
understand. AI-assis
help the discover
do you think clim
is solved? Why do
genomics yet?
solved cancer, AI
ing just more hu
it. I even argue th
e really wants to l
going to require
AI. AI, if don
realise humanity?

DEMIS HASSABIS

SHOULD
WE BE
WORRIED?

OMEGA



Ω
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Speedmaster

“The pace of progress in artificial intelligence (I’m not referring to narrow AI) is incredibly fast. Unless you have direct exposure to groups like DeepMind, you have no idea how fast – it is growing at a pace close to exponential. The risk of something seriously dangerous happening is in the five-year time frame. Ten years at most. This is not a case of crying wolf about something I don’t understand. I am not alone in thinking we should be worried. The leading AI companies have taken great steps to ensure safety. They recognise the danger, but believe that they can shape and control the digital superintelligences and prevent bad ones from escaping into the internet. That remains to be seen...”

ELON MUSK, NOVEMBER 2014

INSIDE DEEPMIND

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“There’s a lot of misunderstanding and unsubstantiated hype from people who are smart in their own domains but don’t work on AI. We’re going to need artificial assistance to make the breakthroughs that society wants. Climate, economics, disease – they’re just tremendously complicated interacting systems. It’s hard for humans to analyse all that data and make sense of it. And we might have to confront the possibility that there’s a limit to what human experts might understand. AI-assisted science will help the discovery process. How do you think climate is going to get solved? Why don’t we have personal genomics yet? Why haven’t we solved cancer, Alzheimer’s? Adding just more humans can’t solve it. I even argue this with Elon – if he really wants to live on Mars, it’s going to require something like AI. AI, if done properly, will realise humanity’s potential.”

DEMIS HASSABIS, APRIL 2015



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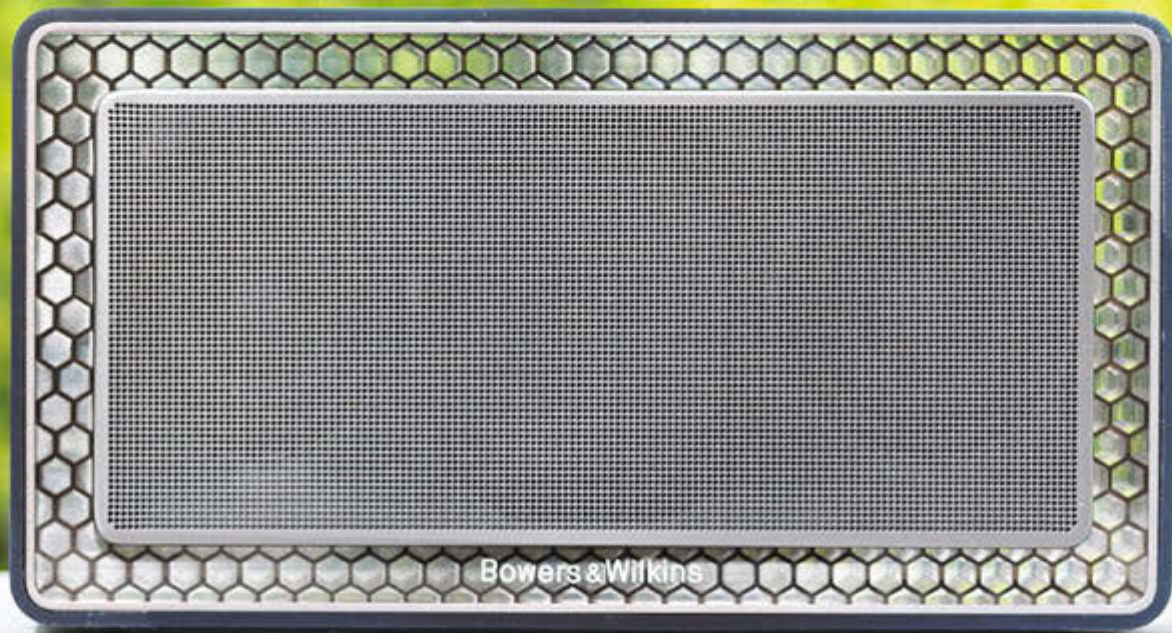


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FEATURE

Deep thinker

Mustafa Suleyman, head of applied AI at Google's super-brain DeepMind, is on a mission to "solve intelligence"



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START

Let's twist again

What a blast: researchers in Ontario are creating DIY tornadoes to help make the next generation of buildings more stable

Above: Jonathan Downey's Airware technology powers UASUSA's 68kph Tempest drone

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PLAY

A real ladies' man

Hollywood director Paul Feig continues to exorcise gender stereotypes with next year's all-female *Ghostbusters* reboot

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Server in the clouds

More than 600 companies now build drones. Can Airware be the operating system to connect them all?

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Phase One ALPA A-series

Cameras that combine lenses and digital backs. Plus: insulated jackets; Bluetooth speakers; Meccano chair; tiny tech

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Life enhancement

Dive like a seal; watch a film for free; make a shot glass out of ice; build a VR headset; make your own wine at home

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Total immersion

Virtual reality is set to explode. Devices such as Oculus Rift are about to impact every sector, from education to medicine

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Brain food and provocations

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Britain rebooted

Twelve experts and thinkers give the new PM their suggestions for change – from schools and agriculture to tax dodging

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The e-resident

The most technologically-savvy nation in the world is a tiny blob off the Baltic coast. Here's why you should be an e-resident



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MACIEK JASIK

New York-based photographer Jasik headed across the Atlantic to join the founders of DeepMind at their London HQ. His mission: to portray the UK firm aiming to “solve” artificial intelligence – a mission Google has backed to the tune of £400 million: “The DeepMind guys are deep thinkers and very driven. We talked about the concerns over runaway AI that have been voiced by Stephen Hawking and Elon Musk, though the DeepMind guys are concerned with beneficial applications, such as medicine. That said, what’s to stop others taking it and applying it to a different realm? But the way AI might enhance human thought is fascinating – would we find a machine’s argument to stop using fossil fuel more convincing than a human’s? I took the portraits of Demis (*below*) as we talked about this – I wanted to show him deep in thought.”



LIAT CLARK

The deputy editor of wired.co.uk, Clark is our guide to the brave new world of virtual reality – and where it’s going next. “When you see VR being demoed in department stores, you know it’s gone mainstream,” she says. “But I’m more excited by the medical applications, such as helping PTSD patients to recover.”



JAMES DAWE

Hackney resident Dawe illustrates our feature on the future of virtual reality. “I started by depicting some of the cutting-edge goggle devices, with these crazy worlds swirling around them,” he says. “VR will affect everything – I can see how my own line of work will eventually take on a more 3D and interactive aspect.”



ÓLAFUR RAGNAR GRÍMSSON

President of Iceland, Grímsson enthuses about geothermal energy in our feature on reinventing Britain – even for those not living somewhere volcanically active. “There are people in central London who have built these home-based geothermal heating and cooling systems,” he says. “You do it house by house, street by street.”



PIPPA MALMGREN

In our Reboot Britain feature, Malmgren, founder of drone maker H Robotics, writes that the key to transforming education lies in how disciplines talk to each other. “We spend a lot of time trying to get kids into tech and STEM,” she says. “We spend hardly any time trying to get poetry and literature into techies. But this matters.”



✚ MAKING WIRED / CREATING A BUZZ

WIRED sent photographer Chris Crisman to visit the Californian HQs of Airware and 3D Robotics, two commercial drone firms conquering the skies: “This story really opened my eyes as to the level of research and development required to get this technology off the ground – and the demand that’s fuelling it. I sense that the hum of drone-propellers will soon be buzzing around us. Change from above.”



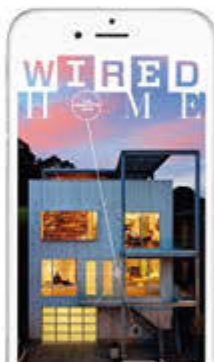
OFF-PAGE

FEEDBACK

WIRED connects

"I feel conflicted about health-monitoring (Future homes will ambiantly monitor breathing and heart rate, wired.co.uk). I would not turn down something that helps watch over a child, but beware Trojan horses. I fear a future where humans are priced out of healthcare. Big data is great for research, but it can also be used to profit the few. Health should not be a commodity." **Toby Roberts**, via wired.co.uk

"The Connected Home supplement is a great way of visualising how the #IoT is actually going to change things, rather than more chat about the connected fridge." **@nick_viney**



"Thought-provoking piece on blockchain by Reid Hoffman in @WiredUK. How long until I can pay for my magazine subscription in bitcoins? :)" **@ne_brown**



"Mine arrived unsealed – should I check for bugs? #policestate #1984" **@chromebookbob**

MAGAZINE

Security at a price

"While you respectfully disagree with the UK and US governments' position on encrypted/secure communications and highlight your point on it being caused by a criminal minority vs the interests of the majority, I would put to you that it is in fact an increasing fundamentalist radical *majority* on top of the criminal element that uses encryption and privacy tools (Privacy special. 05.15). The word 'freedom' that people bandy about in various articles and interviews always comes at a price. Would a world without crypto be less secure? Yes. Would a world whereby security agencies had no way of intercepting communications from terrorists and criminals? I think we all, as individuals who enjoy the freedom you talk about and quite possibly take for granted, should stop occasionally and ask what price would not only you, but your family, friends and loved ones, be prepared to pay." **Francis Younghusband**, via email

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"itsgoingtobehardertoreadcommentsbutwewillgetusedtoit"

(RE: Google may be planning to kill the spacebar, wired.co.uk), Alban Read, via wired.co.uk



MAGAZINE

He got game

"Surprisingly, there's no mention of *Star Citizen's* main rival, *Elite Dangerous* (Lost in Space, 05.15). For a one-off £100 backing I have access to the whole game forever with as many ships as I want, not just an empty virtual hanger. Oh, and I got a lovely star chart to put on my (real) office wall as well." **Cmdr Backer EHJP**, via email

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EVENT

WIRED Health

"Inspiring day at #WIREDHealth on AI, bionics, existential existence, big data and the UK's declining sherry habits @rorysutherland... Brilliant." **@teammjl**

"In other news, I just shook hands with someone who has a bionic arm at #WIREDHealth. So cool." **@mrseb**

"Thanks @WiredUK for this amazing event #WIREDHealth. Definitely the most mind-blowing conference ever!!" **@denisvalle5e**

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Great idea... on paper

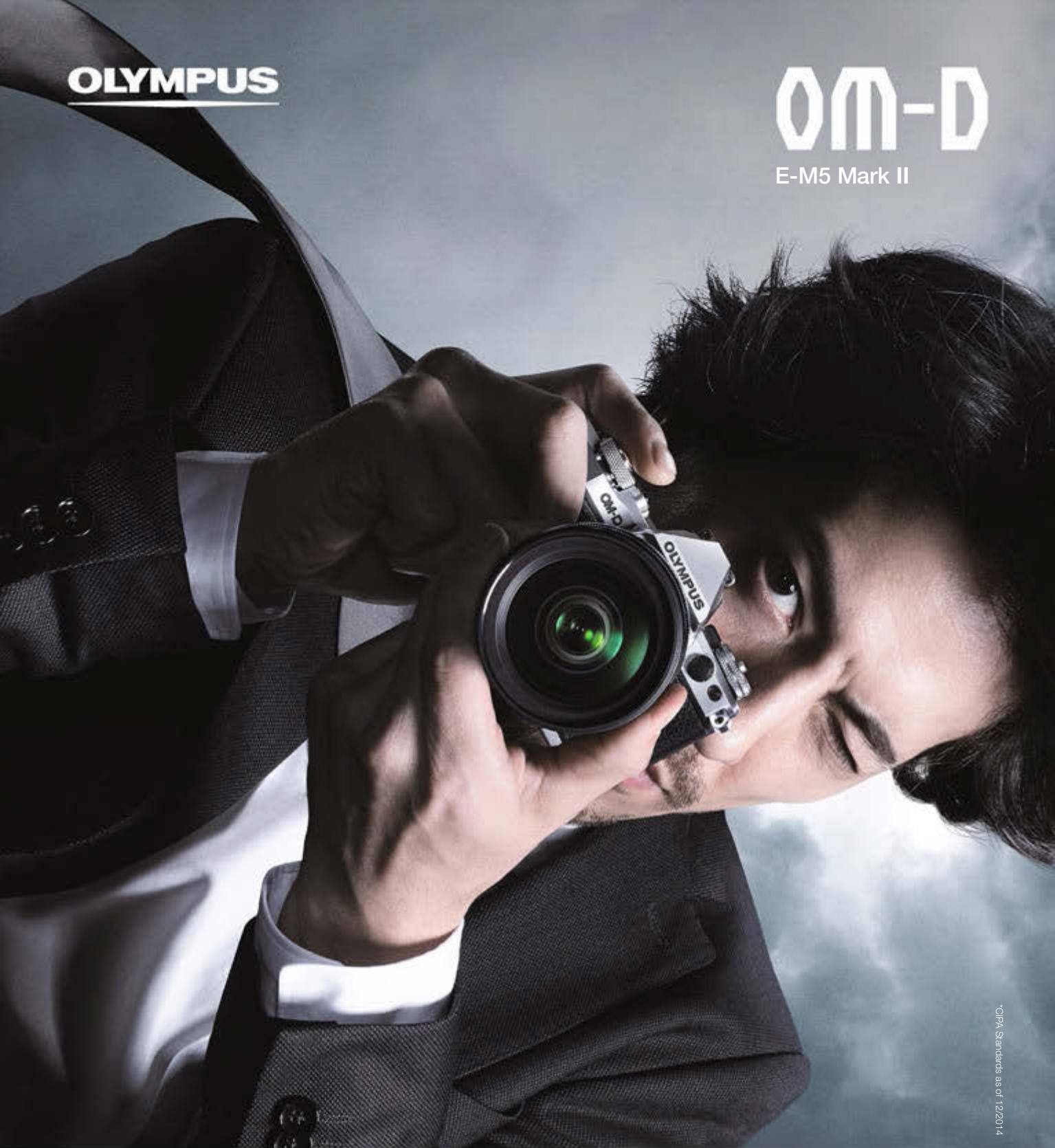
"It is 2015 now... and I have not heard of graphene-made e-paper yet." **Deepanjan Biswas**, via Facebook (RE: Graphene-made e-paper by 2015 – a wired.co.uk story from 2012)

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FROM THE EDITOR

How would you feel about a powerful artificial intelligence being set loose on the world? This super-being would be smarter than any human, capable of performing un-guessed of simultaneous tasks – and would then make its own independent decisions about actions to take. And it would be owned by one of the world's biggest global corporations – one that knows where you are, what you're emailing, who you're hanging out with, even what you're thinking about... Sounds like a plot from Hollywood, right?

Such thoughts were in the back of my mind when I first visited DeepMind, the London AI startup bought by Google last January for £400 million. Not much is known about DeepMind, beyond its website's bold declared mission (to "solve intelligence"), and some academic papers published by a team of scientists now 100 strong. When, after 15 months of negotiation, I managed to gain access to the founding team, I was curious to know how closely Google was directing its research, how near it was to creating artificial general intelligence (the type that can adapt to all sorts of diverse tasks, just like humans), and the role ethics would play in the team's thinking. After all, people such as Elon Musk, Stephen Hawking and Steve Wozniak had all recently declared their concerns for humanity's future if an AI was allowed to develop autonomy.

What I found was eye-opening, but far removed from Hal 9000 and *Terminator's* Skynet stereotypes. The DeepMind team insist that an AI is needed if science is to overcome some of society's greatest challenges – helping humans tackle energy shortages and climate change, solve diseases such as cancer, take us to other planets. But that's going to require a decades-long effort, one which will require the funding of a mission-driven company such as Google before such a research project pays for itself. Of course, Google will benefit commercially in the short term – its advertisers will presumably get better response rates from improved YouTube video recommendations or more context-aware search – but



Demis Hassabis,
cofounder of
DeepMind, at its
London HQ

this doesn't seem like a purely commercial bet. Larry Page is impatient for a world where raw information is more efficiently turned into actions and knowledge. And with all respect to humans,

our collective brain will never scale as effectively as a giant, efficient AI.

We now have a new government in Britain. But the election campaign didn't expose many new ideas – certainly none that excited the WIRED team. So we repeated a project that we undertook at the last election five years ago: we asked the smart thinkers in our network to come up with constructive and fresh policy ideas that we could set before the new administration. From energy innovation to new approaches to employment, we hope we can kickstart a few useful debates (and we want you to come up with your own suggestions – send them to rants@wired.co.uk). We are, though, mere humans. I'm intrigued to know what policies an AI would suggest...

PHOTOGRAPHY: MACIEK JASIK

DMA MAGAZINE OF THE YEAR 2014 • DMA TECHNOLOGY MAGAZINE OF THE YEAR 2014 • BSME ART DIRECTOR OF THE YEAR, CONSUMER 2013 • PPA MEDIA BRAND OF THE YEAR, CONSUMER 2013 • DMA TECHNOLOGY MAGAZINE OF THE YEAR 2012 • DMA EDITOR OF THE YEAR 2012 • BSME EDITOR OF THE YEAR, SPECIAL INTEREST 2012 • D&AD AWARD: COVERS 2012 • DMA EDITOR OF THE YEAR 2011 • DMA MAGAZINE OF THE YEAR 2011 • DMA TECHNOLOGY MAGAZINE OF THE YEAR 2011 • BSME ART DIRECTOR OF THE YEAR, CONSUMER 2011 • D&AD AWARD: ENTIRE MAGAZINE 2011 • D&AD AWARD: COVERS 2010 • MAGGIES TECHNOLOGY COVER 2010 • PPA DESIGNER OF THE YEAR, CONSUMER 2010 • BSME LAUNCH OF THE YEAR 2009

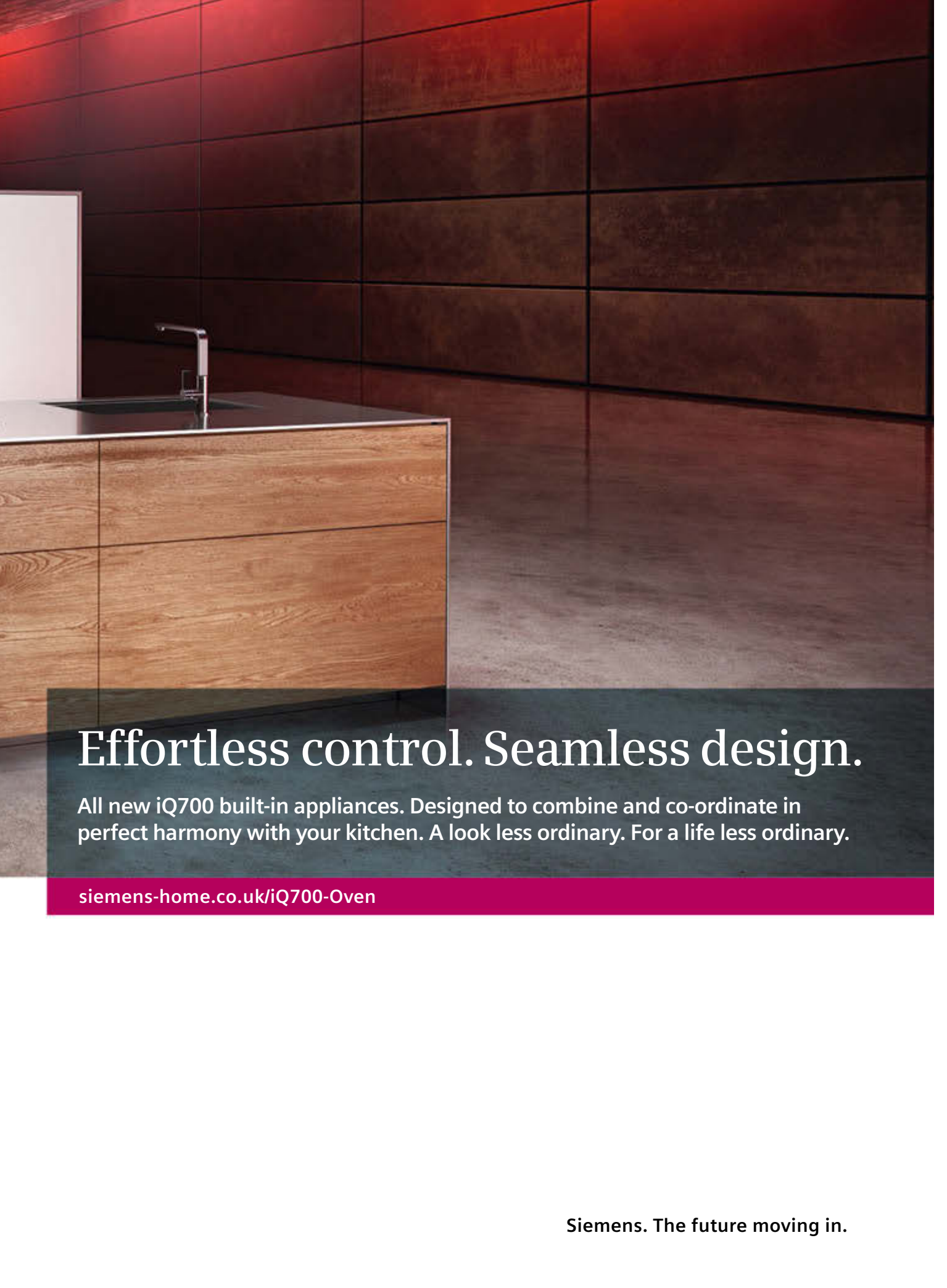


David Rowan



A dish is only as fine as its ingredients. It's a rule that equally applies to kitchen design. Introducing the iQ700 Built-in Appliance Range – designed to create a Siemens kitchen that will set the benchmark in coordinated design and intelligent technology. With front panels controlled by touch, that perfectly harmonise with one another so you can arrange the appliances

your way. And thanks to the intelligent combined heating technology, varioSpeed, you're free to live a life less ordinary and cook your way too. Prepare dishes with speed and save up to 50% of the cooking time by combining the iQ700 integrated microwave with more conventional cooking options.



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siemens-home.co.uk/iQ700-Oven

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TAKE A WALK, ROVER

Last year, Nasa's *Opportunity* rover set the off-world driving record at 40.25km after ten years on Mars. The HiRISE (High Resolution Imaging Science Experiment) camera that took this picture of the planet's Proctor Crater, however, is exploring it 100km² at a time.

"We see the whole planet," says Alfred McEwen, the University of Arizona professor who heads the research project. "The rovers just see one small area – all the distance *Opportunity* has travelled would fit in one HiRISE image."

Armed with the largest reflecting telescope to be sent on a deep space mission, the camera takes 11 photos a day at 30cm per pixel resolution. And it may have found water: pictures have shown recurring slope lineæ – deep markings on the planet's surface.

"It's difficult to come up with another explanation for these features," says McEwen. "Water is the best candidate."

Sophia Epstein
hirise.lpl.arizona.edu

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ONE EVENING IN 2009, ILAN

Zechory, then an engineer at Google, hedge-fund manager Tom Lehman and another friend, Mahbod Moghadam, started debating the meaning of the lyrics of the Cam'ron song "Family Ties". A day later, they'd built a website, Rap Genius, where anyone could annotate rap lyrics. Today the site, simply called Genius, attracts around 30 million visitors a month, who elaborate on not just the deeper meanings of rap lyrics but all forms of music, literature, technology and news. "The pivot actually happened on day four, when users started annotating not just lyrics in all genres of music, but also poems," says Zechory.

The Genius community includes a verified-artist certification, with contributors such as Kanye West and Pulitzer-winning writer Junot Díaz. "There is a key difference between us and Wikipedia," says Lehman. "Wikipedia won't allow Barack Obama, for example,

to contribute to his own page. But there might be something that only he knows that could contribute to the public understanding of who Obama is."

Zechory and Lehman's next goal (Moghadam resigned from the company in May 2014) is to turn Genius into an extra layer of content on the web, rather than a standalone site. "We want to take annotation to wherever people experience content, on and off the internet," says Zechory. They, for instance, envisage that visitors will soon be able to access annotated lyrics when playing a song on iTunes or Spotify, or scientific papers as they undergo real-time peer review by annotation. They've raised \$97.7 million in total funding, though they still haven't cracked their revenue model. "The site started out as an art project," says Lehman. "But in order to last for hundreds of years, it's got to make a lot of money. We want to see Genius annotations across all of human culture and build a lasting monument to knowledge on the internet." João Medeiros genius.com

Taking note

The founders of Genius – formerly Rap Genius – want to annotate all human culture

Alternative head:
"Keppe's rewrite"

HOW GENIUS'S ANNOTATORS ARE EXPLAINING CULTURE

Title	Genius notes
If by Rudyard Kipling If you can keep your head when all about you/ Are losing theirs...	"The phlegmatic stoicism of the British in the Blitz is a good exemplifier of the ideal of the poem." <i>lizzie_d</i>
Take Me To Church by Hozier My lover's got humour/ She's the giggle at a funeral	"Laughter at a funeral is the first hint that this song is sacrilegious." <i>DaveHowell</i>
Know Yourself by Drake Runnin' through the 6 with my woes	"416 is an area code for Toronto. Woes is an abbreviation for "whoaie", or people close to Drake." <i>UFO</i>

Valued at \$900m, Genius received \$40m in funding in July 2014 from Andreessen Horowitz and others.

Other contributors include Eminem, Nas, Marilyn Manson, Foxglove and George Clinton.

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Archaeologists are really digging Crossrail: the London railway has unexpectedly turned into Britain's largest archaeological project. During its six-year tunnelling through the city centre – something archaeologists have never been allowed to do – more than 10,000 artefacts have been discovered across some 30 sites. And it's going to take at least another five years to complete. "It was pretty clear from the route that there was going to be some really good archaeology," explains lead archaeologist Jay Carver. "It's an ideal cross section across London." Digs have revealed evidence

of early humans dating back to 7000 BCE. Roman hairpins were found in Moorgate, and a Tudor bowling ball, made of South American wood, turned up at the site of a medieval manor in Stepney Green. It's unearthed a few mysteries, too. For example, a curiously large number of rare Roman horseshoes have been found within a relatively small area, to the northern part of Roman Londinium. "It could be something associated with the military," speculates Carver. Elsewhere, a dig in east London revealed the Thames Ironworks shipyard. "London's shipbuilding history is almost totally unreported in archaeology prior to Crossrail happening," says Carver. His goal: to recreate a large slipway as part of a future museum exhibit. "We kept some of the timbers back for that very reason." **Chris Baraniuk** crossrail.co.uk

Layers of London

Crossrail has archaeologists rewriting the capital's history



The Parisian skyline

has been redrawn – this 50-metre apartment block is the tallest building to be built in central Paris since the early 70s. Paris is one of a handful of developed cities to remain horizontal, largely because of restrictions on building height put in place in 1974. But when the Conseil de Paris lifted the ban in part of the 13th arrondissement in 2011, it led to this €24.5 million (£17.6m) residential building.

"Our goal was to make a building that explained this transformation from a horizontal city to a vertical one; the two towers create a skyline," says Jean-Christophe Masson, lead architect of the project, whose firm

Hamonic + Masson designed the building with fellow architects Comte Vollenweider. The taller block is all social housing, whereas its 37-metre cousin comprises 96 private apartments.

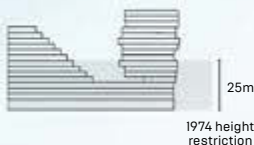
Masson says that another 50-metre building is being built next door. "From inside, people will be able to see Paris differently," he says. "It's not just this picture for tourists – that's why we call it Grand Paris."

Sophia Epstein

hamonic-masson.com

Move over, Eiffel Tower

The lifting of a ban on skyscrapers has led to central Paris's first high-rise in decades



WINK AND YOU WON'T MISS IT

Ever wanted to pinch and zoom in the real world?

Eric Tremblay, an engineer at Swiss university EPFL, may have found a way: his lab has created a zoomable contact lens to give humans 2.8 times normal vision. "We're at the boundary of what's possible in terms of optics fabrication," says Tremblay.

Mirrors sit inside the 1.5mm-thick lens, through which light is channelled by polarising films. Each time the light bounces off the mirrors, it changes focus. This broadens out the path of the light and projects a larger image. The lenses need to be worn with glasses that can control the zoom with a wink.

The original goal of the Darpa-funded project was to give soldiers better vision, but it's now being aimed at civilians with defects such as macular degeneration. Before then, however, testers need to find out how to keep it in the eye without restricting air. We always knew the Six Million Dollar Man was ahead of his time. **Chris Stokel-Walker** *lapd.epfl.ch*

PHOTOGRAPHY: TAKUJI SHIMMURA. ILLUSTRATION: THOMAS HEDGER





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APPS OF THE MONTH



KHAN ACADEMY

Online education organisation Khan Academy already had an app, but this iPad version bundles all of its 150,000-plus lessons and videos together for the first time. The series is just as accessible in interactive app form as it is on the web. *iOS, free khanacademy.org*

WIRED



QUALITYTIME

If you feel you spend too much time on social media, this app could be for you. It will keep tabs on how many minutes per day you spend using your favourite apps and can lock you out of them or alert you to overuse. *Google Play, free qualitytimeapp.com*



TIMELINE

This news aggregation app not only gathers together stories you should have read, but also puts them in context. By placing stories chronologically with background articles, you can explore the history of developing news items. *iOS, free timeline.com*



MAPILLARY

If you have a passion for citizen science or cartography, *Mapillary* – a crowdsourced version of Google Street View – might appeal. Supply photos through your smartphone as you go about your business. *iOS, Android and Windows Phone, free mapillary.com*



MATERIALS LIBRARY

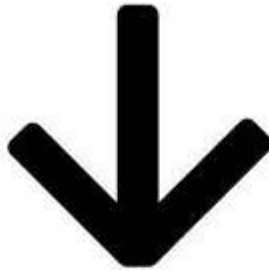
From the Institute of Making comes this searchable database of materials. Along with images and text, there's now video and audio content to augment the catalogue's contents. *iOS, free instituteofmaking.org.uk*



FUNNY OR DIE WEATHER

Comedy site Funny or Die and meteorology might not seem like an obvious collaboration. But to WIRED's surprise, the merging of the two has resulted in an elegant, user-friendly weather app with bonus facts and funnies. *iOS, free fodweather.com* **Katie Collins**

WEIRD



Curator of the gene pool

Maria Bitner-Glindzicz is collecting our genomes to fight inheritable conditions

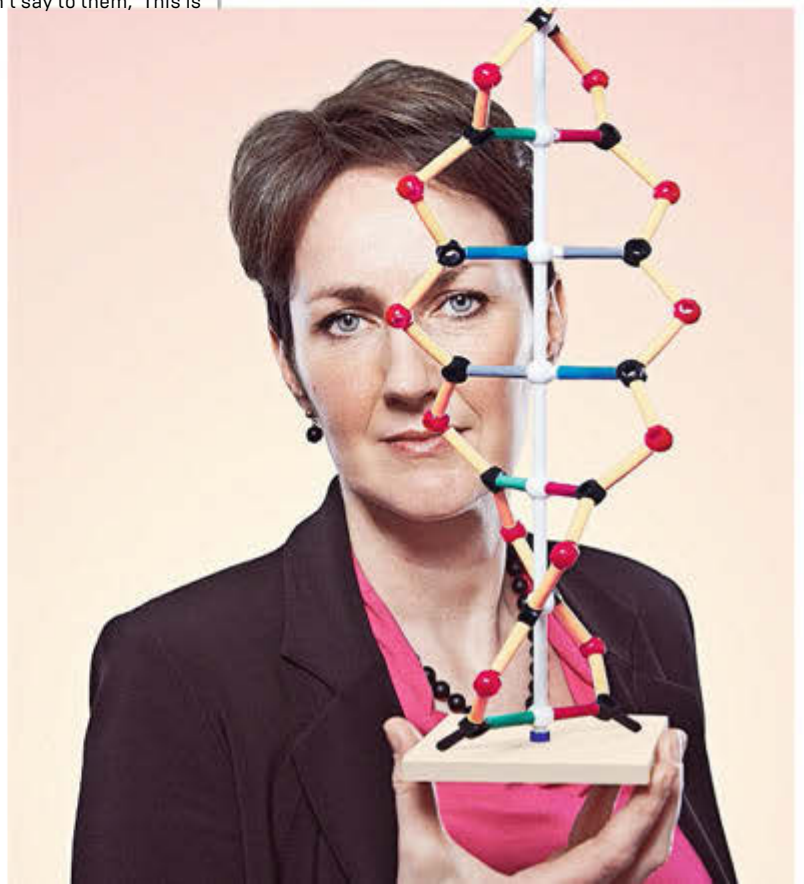
MARIA BITNER-GLINDZICZ

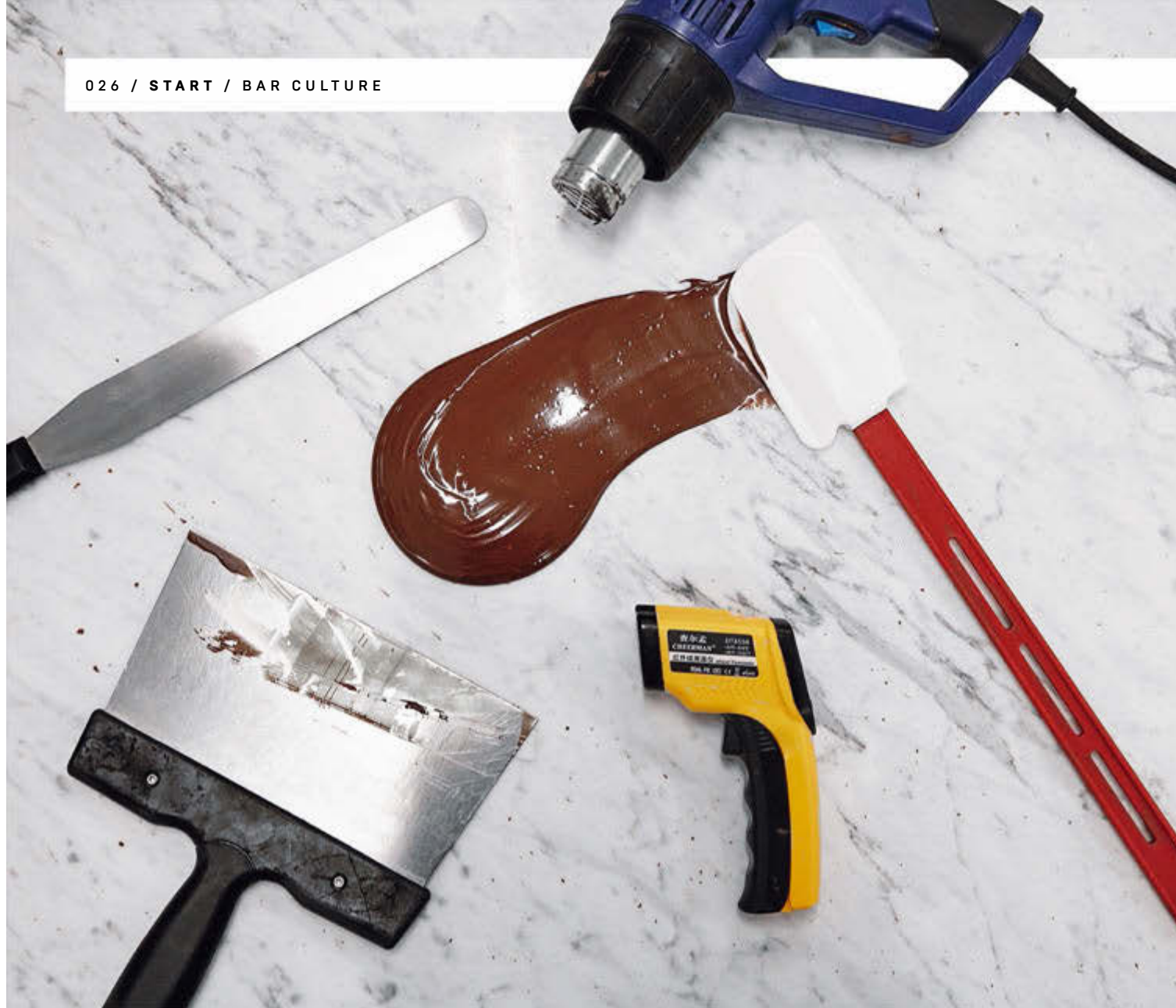
is a genome hunter. Her goal: to help gather 100,000 genomes from around the UK to diagnose and cure rare genetic diseases and cancer. She is a clinical and molecular geneticist at Great Ormond Street Hospital, where she treats children and adults with rare inheritable conditions such as genetic deafness. "These are diseases that affect less than one in 2,000 people but cause symptoms that we can't figure out – learning disabilities, complex epilepsy, kidney problems, cardiac issues and early-onset dementia," she says. "Many of the children we see don't have a diagnosis yet. We can't say to them, 'This is

the cause of your condition and this is how it came about'. And we can't tell their parents that it might happen again to their other children. We don't know the cause, so we don't have any information."

To grapple with this, Genomics England has launched the 100,000 Genomes Project as a three-year nationwide initiative to collect and analyse the genomes of families with rare syndromes and patients with cancer. Bitner-Glindzicz, 52, has recruited

1,000 patients in the North Thames region of England as part of a pilot. There have already been diagnoses, including two brothers with inherited nerve damage due to a newly discovered gene mutation; they are now set to join a treatment trial. Studying rare diseases also gives insight into common ones. "For instance, causes of some rare genetic skin diseases have helped us better understand causes of eczema," Bitner-Glindzicz says. "What we hope to understand here is what's going on in the human body generally." **MV** genomicsengland.co.uk





GRINDER

Five stone grinders are on view at work in the London store. "After an hour or two the chocolate starts to break down," says Rick Mast. "Because of the very high butter content of the cocoa beans, it starts to melt and looks like melted chocolate."



WINNOWER

"The old way of winnowing would be romantically taking a wicker basket of cracked cocoa beans and throwing it up into the wind," explains Mast. "The wind would take the lighter shells away and leave the nibs." The brothers have replaced the wind with a fan in this custom-built machine.

HEAT CONTROL

The temperature probe (*centre*) is to monitor the heat of roasting beans – which makes sure that they reach a specific roasting profile. The heat gun (*top*) is for warming the chocolate, as well as the grinder and moulds, before the chocolate goes into them.



LIKE TWO BEARDED WILLY WONKAS, THE

Mast Brothers have turned chocolate from a treat into an experience. Their flagship London store opened in Shoreditch, in the east, in February, with their chocolate-making factory displayed behind a glass window for all to see. “We just wanted to let everyone experience what we do,” says Rick Mast. “I want you to be able to come in and see your chocolate being made and be connected to that process. You have all

those smells and sounds and sights that you can’t get anywhere else.”

Despite having no formal training in confectionery, the brothers began making chocolate in Brooklyn, New York, out of sheer curiosity. They made the first couple of batches in their apartment, but have now refined the process: sourcing beans from Peru to Papua New Guinea and using custom-made machines built for small-scale production. “We believe that quality is tied into the person making it, so all of our equipment is kept at a human scale,” says Mast.

Their methods and equipment, from the winnowers to the grinders, are based on traditional techniques. “We’re taking old ways of doing things and modernising them,” says Mast, adding that stone-grinding is no longer common practice, but preserves the flavour more than modern alternatives. “From bean to bar, you’re talking about a 40-day process.” In our series on specialist tools, WIRED tours their kitchen. **SE** mastbrothers.com

WORKTOP

The Mast Brothers’ signature cube-shaped treats are made here: scales are for weighing, the induction stove for heating, and a hand

blender to turn the ganache into an emulsion. The confections are then piped into shape and the palette knives cap them.

Tools of the cocoa trade

Mast Brothers reveals the secret of high-quality chocolate



Digital extra!
Download the WIRED app to see more of the Mast Brothers’ kitchen

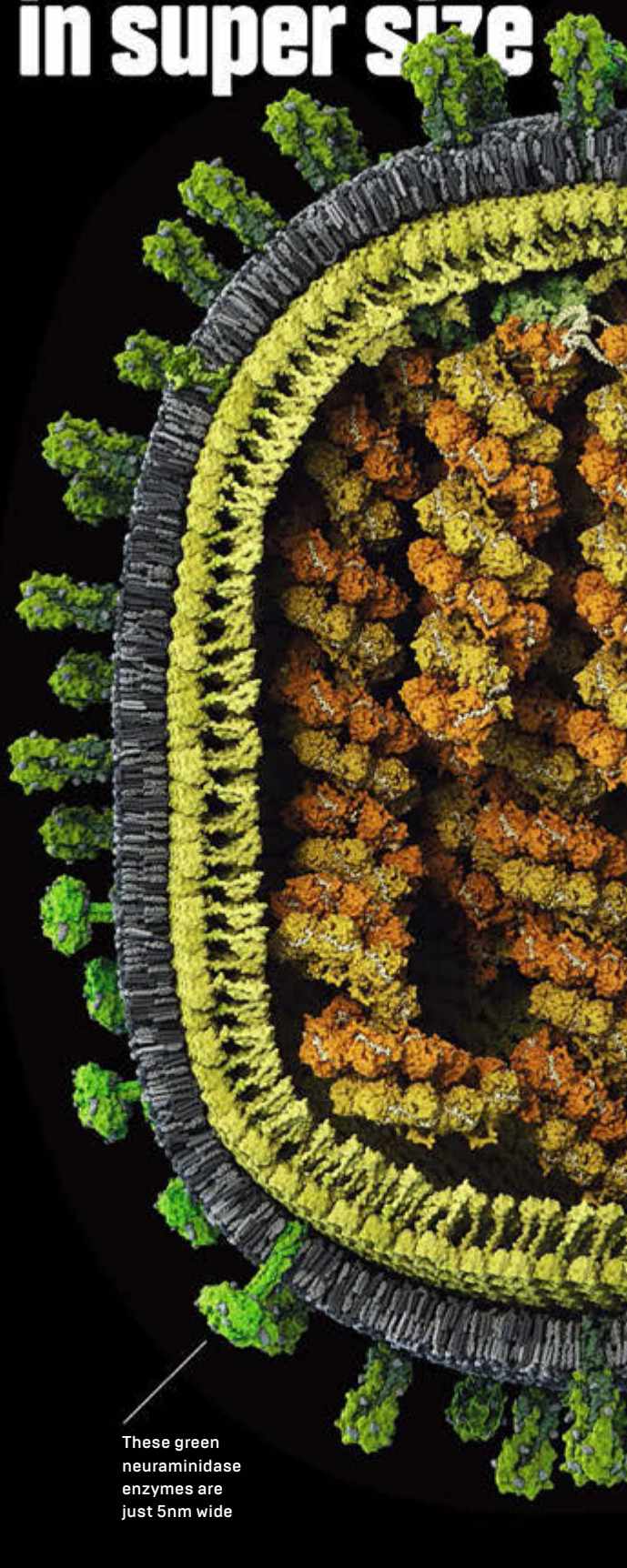


Catch the flu in super size

THIS IS THE MOST

detailed 3D model we have of the influenza virus. Built by Visual Science, a Moscow-based scientific design studio that creates hyper-accurate 3D replicas of microscopic objects, the model aims to boost understanding of the bug. "We depict the tiny world as accurately as possible," say Visual Science CEO Ivan Konstantinov. "And we do it in the most attractive way possible." To capture it, dozens of research papers on the virus were analysed, and the team consulted immunologists about their research.

Now the company is working on replicating the mutated poliovirus that proved vaccine-resistant in a 2014 outbreak in the Democratic Republic of the Congo. "Our idea is to make models of the common and new polioviruses," says Konstantinov, "to demonstrate how minor changes may result in dangerous shifts in its properties." These models compile years of research in a way that can be visually explored, giving researchers a new perspective into the inner workings of diseases. **SE** visual-science.com



These green neuraminidase enzymes are just 5nm wide

EARLY ADOPTERS



WHAT'S EXCITING...

SIMON EDWARDS

Cofounder,
Shuttlecock

"**Leaf.fm** creates a marketplace for artists and their fans to interact, share music and generate revenue. By placing merchandise and concert tickets in-app with a free music streamer, Leaf.fm is making it laughably easy to follow and support your favourite bands."



WHAT'S EXCITING...

JAMES BOOTH

Founder and CEO,
Rockabox Media

"Withings' **Smart Body Analyzer** is a set of scales that measures all sorts of things, which is then recorded via an app. To make things fun, there's gamification – you can battle over steps taken each day. And reviewing multiple health-related elements over time is fascinating."



WHAT'S EXCITING...

TIFFANY PHAM

Founder and
CEO, MOGUL

"The **PhotoWonder** app is essential. It has immensely useful image-editing tools, especially when used on photos of people, and filters to rival *Instagram*'s. I particularly like the 'One-Click' function, which improves lighting and image quality at a stroke." **SE**



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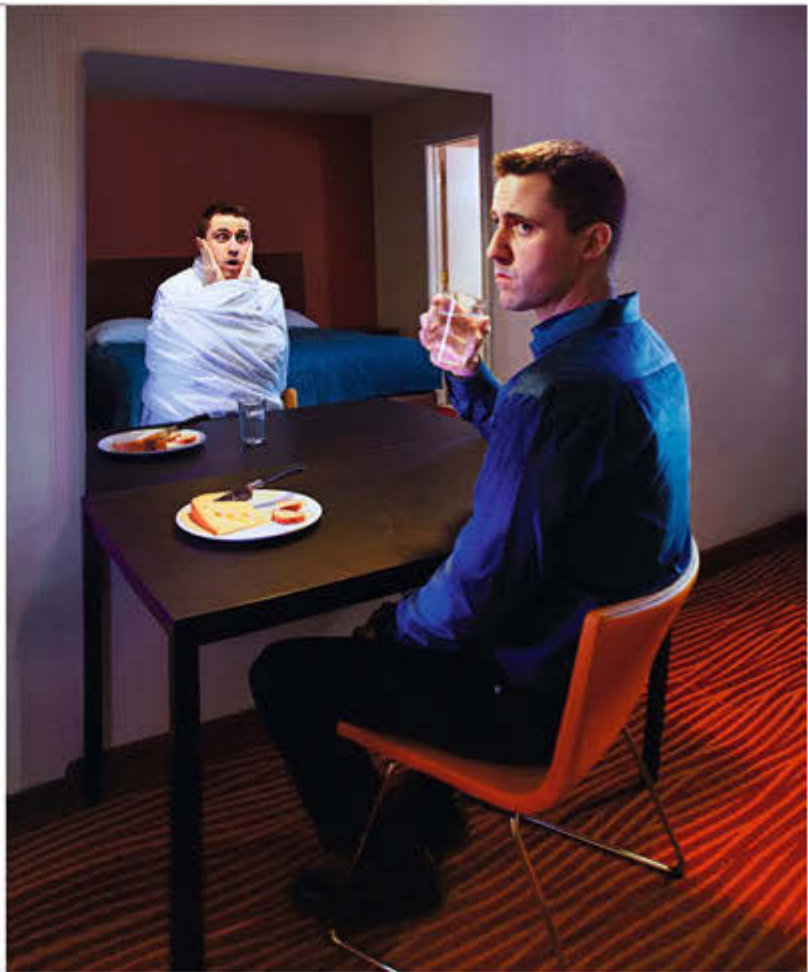


ARE AMERICANS GETTING TANGLED TO

death in their bedsheets because they're eating too much cheese? The answer, clearly, is no. But you could be forgiven for considering the possibility – for a moment at least – when you see Tyler Vigen's graph showing a close correlation between the number of US citizens meeting their end that way and per capita consumption of cheese over a nine-year period. "Two sets of data might appear to be strongly linked but correlation does not equal causation," says Vigen (*right*), a student at Harvard Law School who set up the website Spurious Correlations in May 2014, to hammer home this point light-heartedly. "There is a danger that people see correlations presented in the media and assume a causal link, so we need to look at this sort of thing critically."

Vigen, 23, wrote a program that combs large data sets published by the US government for statistical correlations, and converts them into graphs. It produces a new graph every minute – 42,888 so far – showing connections between bizarre incidents such as margarine consumption and divorce rates in Maine, for example, or the number of people drowning in swimming pools each year and the number of films in which Nicholas Cage appeared. Visitors can discover their own wacky correlations by picking variables to compare from a menu. Vigen posts the most interesting, as voted by visitors, on the website.

A month after he launched Spurious Correlations, Vigen saw a study that reported a strong correlation between Atlantic hurricanes with female names and number of fatalities. The authors claimed that hurricanes with women's names are more deadly because we don't take them as seriously. But other researchers demonstrated that the correlation was likely a statistical fluke. "I want people to be wary of these statistics we see in the news," says Vigen, whose book of meretricious data relationships, *Spurious Correlations*, is out now. "It just shows how you have to question these things." **Daniel Cossins** tylervigen.com



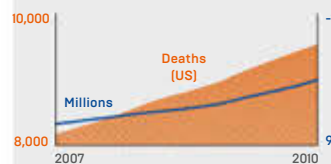
PHOTOGRAPHY: LIAM SHARP

Eat cheese... and risk strangulation

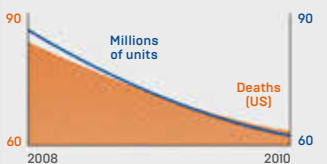
Tyler Vigen is master of the spurious correlation

WIRED'S TOP-FOUR SPURIOUS LINKS BETWEEN VARIABLES

- Suicides by hanging, strangulation and suffocation
- Visitors to Disney's Animal Kingdom



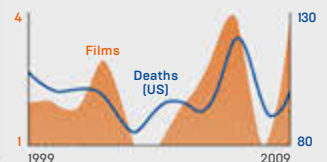
- Number of Americans electrocuted by power lines
- Amount of video games sold in the UK



- Number of worldwide non-commercial space launches
- Number of US children killed by parents



- Number of films Nicolas Cage appeared in
- Number of Americans who drowned by falling into a swimming pool





THIS IS NOT A WATCH

It's 689 calories burned this morning
with 4,300 songs at my control.
5 perfect group selfies at the party
with 25 Facebook notifications the next day.



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T

THESE SUBMARINE TOWERS REPRESENT THE WORLD'S FIRST FULLY operational wave plant. Designed by Australian company Carnegie Wave Energy, three of these structures are tethered to the ocean floor just off Perth, where they convert wave power into emission-free electricity. Together, they generate 720kW annually, powering part of a nearby naval base. And now Carnegie Wave Energy wants to go global with these units. "You can link together as many of them as you need," says Michael Ottaviano, the company's managing director. "That's where we see this going – large-scale wave farms."

The current model is the CETO 5, an 11-metre-wide platform that makes electricity by using waves to push a pump at its base. The pump sends a stream of pressurised water shooting through pipes that run along the ocean floor.

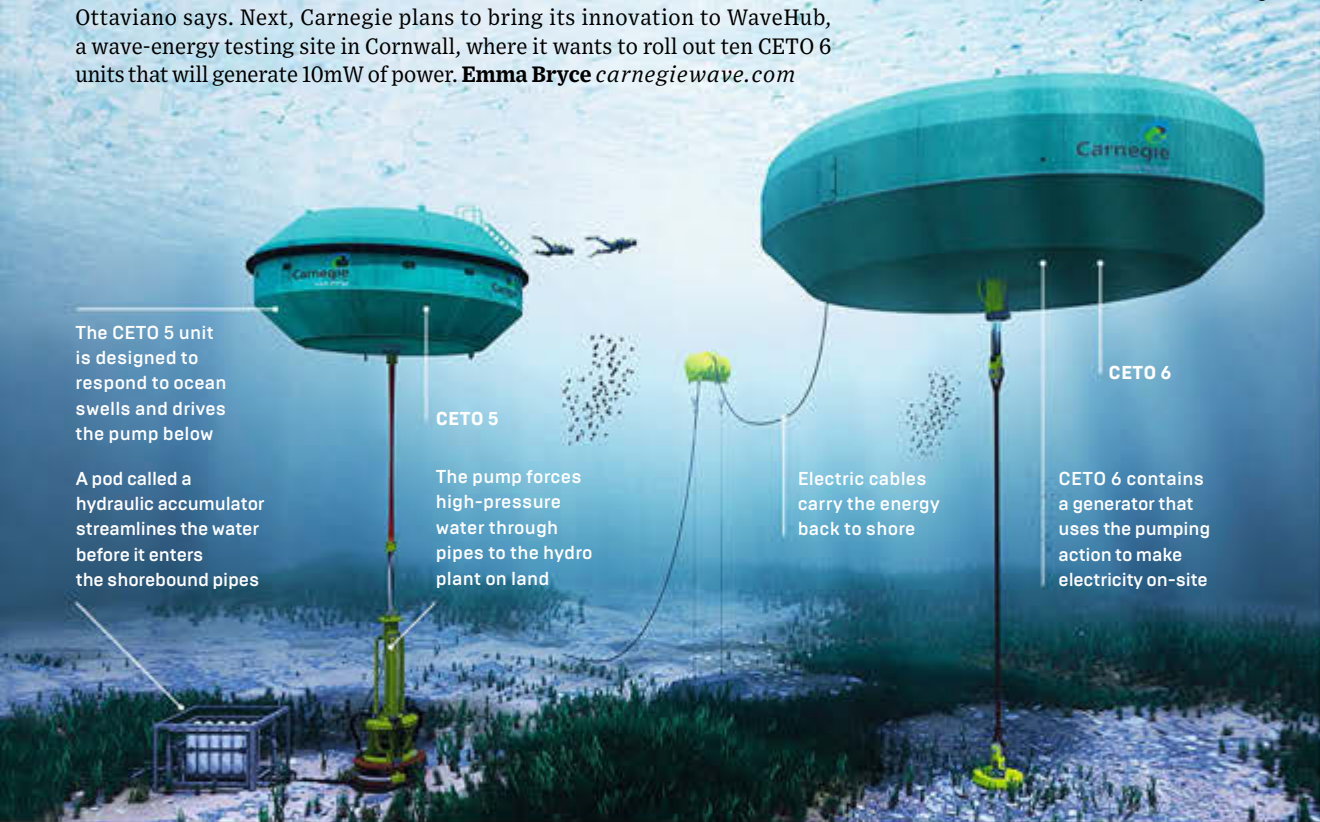
Those generate electricity at a land-based hydroelectric plant, where the force

of the water rotates the turbines. The pumping action can also be used to drive desalination plants and make fresh, drinkable water. Now Carnegie is upgrading to CETO 6, which will produce power completely offshore by using the pumping action to drive a generator within the buoy, making electricity on site. Subsea cables will then wire the power back to land. With its 20-metre diameter, CETO 6 can produce 1mW of energy; by 2017 Carnegie wants to tether three units off Perth.

Compared to wind and solar power, wave energy is denser: by area, Carnegie's wave farms can generate four times more energy than solar farms, Ottaviano says. Next, Carnegie plans to bring its innovation to WaveHub, a wave-energy testing site in Cornwall, where it wants to roll out ten CETO 6 units that will generate 10mW of power. **Emma Bryce** carnegiwave.com

Surf's up

These wave farms help to power an Australian naval base – and they're coming to Cornwall



The CETO 5 unit is designed to respond to ocean swells and drives the pump below

A pod called a hydraulic accumulator streamlines the water before it enters the shorebound pipes

CETO 5

The pump forces high-pressure water through pipes to the hydro plant on land

Electric cables carry the energy back to shore

CETO 6

CETO 6 contains a generator that uses the pumping action to make electricity on-site

YOUR INSURER IS TRACKING YOU



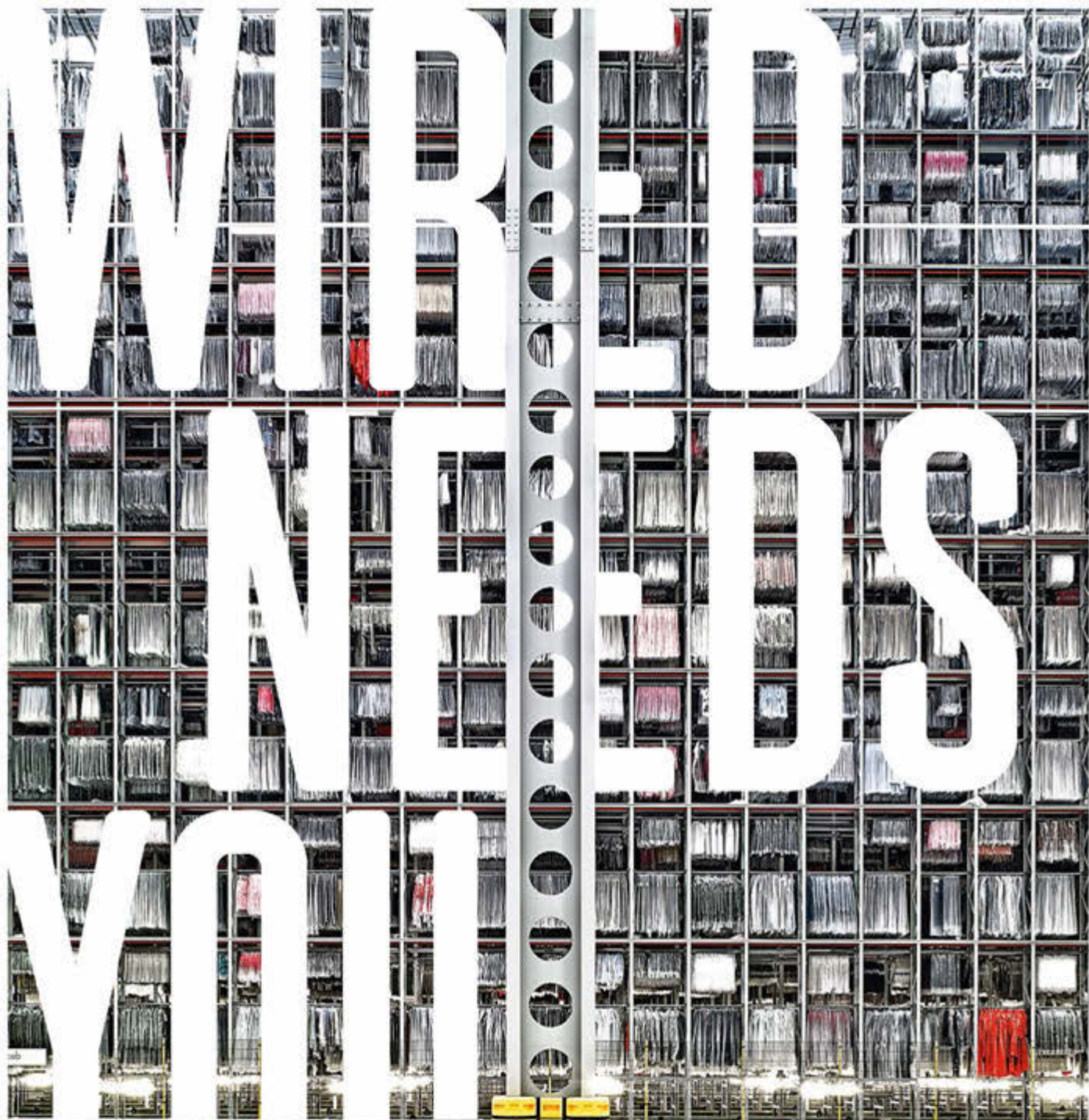
First, devices were installed in your car to monitor how safely you drive. Now, health insurance companies are using wearables to track your day-to-day health. Curious about how last night's kebab could have affected your premiums? Ask these guys. **SE**

JOHN HANCOCK
The American insurer is offering a rewards programme alongside partner The Vitality Group: the more you exercise, the less you pay. Customers get a free Fitbit, which tracks their exercise routine and gives discounts – or markups.

OSCAR
This New York-based health insurance startup has partnered with tech company Misfit Wearables to link its customers' biometric information to their insurance plan. Those who keep healthy can receive up to \$20 (£13) each month in Amazon gift cards.

CIGNA
After distributing BodyMedia armbands to the employees of one of its corporate customers in a pilot programme, insurance company Cigna launched a "healthy rewards" discount programme, using the bands for its other customers.

ILLUSTRATION: PARKO POLO



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WIRED

THE BIG QUESTION

WILL PERSONAL DATA PRIVACY EXIST IN TEN YEARS' TIME?



GABRIEL WEINBERG

FOUNDER AND CEO, DUCKDUCKGO

"The future of personal privacy depends on how much we demand more choice, control and transparency. Companies and governments could explicitly tell you what is happening to your personal information. They could allow you to opt out. They could give you granular control of your data. They could even tell you what you're getting when you give out pieces of information. Disclosure requirements could mimic those in areas like credit cards and mortgages, where bigger risks are highlighted. In other words, there's a lot we could do. If you like that future, demand it." **Kathryn Nave**



NICK MATHEWSON
CHIEF ARCHITECT,
THE TOR PROJECT

"Governments have spent years declaring themselves simultaneously pro-security and anti-crypto; anti-hacker and pro-spy; pro-privacy and pro-identification. Meanwhile, corporations have been promising citizens more privacy, advertisers more targeting and consumers more features. Until we can face up to these contradictions, our desire for privacy will remain unfulfilled."



HARRIET PEARSON
PARTNER,
HOGAN LOVELLS

"With technological change occurring at a breakneck pace there is huge pressure on the legal and social frameworks that are supposed to deliver on our expectations of privacy. More than 100 countries have enacted data-privacy laws, but how will those laws evolve? How will businesses meet consumer expectations in a global marketplace? How will government limit its reach? Important debates ahead!"



RENATE SAMSON
CHIEF EXECUTIVE,
BIG BROTHER WATCH

"When all aspects of our lives become connected through the internet of things, the line between physical and online will blur. A move towards privacy will grow as the risks from oversharing become more pronounced. Privacy by design will become an essential part of R&D for new technologies. Control over personal data, through encryption and consent, will be integral to the security of society."



IAN GOLDBERG
ASSOCIATE PROFESSOR, CHERITON
SCHOOL OF COMPUTER SCIENCE,
UNIVERSITY OF WATERLOO

"Privacy is not only a personal right; it is also a benefit to society at large: a society without privacy is a society without freedom or personal autonomy. We are already seeing an increase in the use and deployment of encryption and other privacy technologies as the default way people communicate online. I expect to see more of this trend in the future."



PATRICK JACKSON
CTO,
DISCONNECT

"In the wake of intense media coverage surrounding mass data breaches and surveillance, people understand more than ever before that any data they share may eventually become public or accessed in ways they do not like. In the coming years we will see mass adoption of products that encrypt data, minimise collection of data and provide more transparent data-sharing policies."

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TICKETING PARTNER 



To form tornadoes, this chamber usually provides suction. But for this downburst, pressurised air is ejected instead

NEEDED TO SIMULATE A STRONG TORNADO? THE WIND Engineering, Energy and Environmental Research Institute (WindeEE), which opened in October 2014 at the University of Western Ontario, Canada, can create hyper-realistic tornadoes and other 3D wind phenomena. “It’s like a chamber in which we can play God with the wind,” says Horia Hangan, the centre’s founding director.

The tornadoes form in a hexagonal chamber 25 metres in diameter with 100 fans unevenly distributed around the base of the walls. Air is pushed inside the chamber through the fans and then louvres in front of them to create a directional wind speed, which results in a twist at the base of the chamber. There is an opening in the ceiling connected to another chamber containing six fans; these run in reverse to

produce suction, creating a tornado. The aim: to improve the way buildings cope with extreme wind, and boosting the energy output of wind turbines. “We are moving to the next scale,” says Hangan. “Modifying engineering guidelines and codes of practice from the wind’s perspective, as opposed to just talking to one architect to fix one building.”

Unlike conventional wind tunnels, the lab can replicate a variety of conditions. “We can put a couple of wind turbines in the chamber and test them in different configurations.” The researchers use the observations to optimise production and to devise ways to protect turbines from storms. We’re blown away. **SE** eng.uwo.ca/windeee



Once the tornado is formed it can move and evolve throughout the chamber, acting as it would in nature

LET'S TWIST AGAIN

What a blast: researchers in Ontario are creating DIY tornadoes in order to improve the stability of buildings

Aluminium obstacles are pneumatically controlled and raised to increase turbulence inside the chamber

A professional podcast recording setup is shown on a white desk. In the background, a wall is covered in black acoustic foam. A silver condenser microphone is mounted on a boom arm. A laptop displays a colorful audio waveform. A black mixer with many knobs is in the foreground, along with a small black device. A vintage-style microphone on a stand is also present.

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LIGHTNING, FOR OBVIOUS REASONS, is hard to study. But Martin Uman and a team of scientists at the University of Florida have a rig that enables them to make their own bolts of electrical power on demand. Their method: head for a storm and send up a rocket on a string.

To trigger the lightning bolts, Uman and company attach 120cm-tall hobby rockets to a 700-metre spool of Kevlar-covered copper wire connected to a strike rod – or whatever they want the lightning to hit. As the rockets launch towards the thunderstorm, the wire unspools and a positive electrical discharge radiates 5km to 10km upward beyond the wire in a jerky zigzag.

Once the positive current makes it to the clouds, it stops flowing for an instant. Then a negative charge shreds back down, hitting the strike rod. A current runs back upwards, and that creates the bright flash known as lightning. So, now that they control where lightning will strike (and can even leave stuff out there to get hit), researchers can gather data about the physics of zaps as well as info about how lightning affects the materials it strikes. Uman's team has found that lightning isn't powerful enough to break the casing on most nuclear waste containers, so phew on that front. The next big project for the university's lightning crew is a Darpa-funded study that uses lightning to learn about the propagation of radio waves used for submarine communications. After that? May we suggest a DeLorean with a flux capacitor? **Neel V Patel**

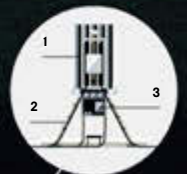
Bolted down To spark lightning, launch rockets

A Florida University team can summon zaps on demand



THE LIGHTNING MACHINE

1. Rocket tubes
2. Insulating fibre-glass launch supports
3. Electronics box for measuring flow of current



One million fps:
speed of the
camera used
to document
the strikes



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MEDTECH STARTUPS RISING IN THE EAST

South Delhi is reinventing itself as an Indian Silicon Valley. Its new tenants: medtech startups. In 2013, India had a record-breaking \$350 million (£223m) in private-equity healthcare investments, and global investors such as the Bill and Melinda Gates Foundation, Dell Foundation and Sequoia Capital have set up shop there. Here are WIRED's five top picks from the area. Esha Chhabra

1

WRIG NANOSYSTEMS

IIT graduate Ambar Srivastava developed the TrueHb, an \$80 haemoglobin meter. He wants to use it to collect data on the number of anaemia cases in India – a major cause of maternal deaths. truehb.com

2

CONSURE

Nishith Chasmawala and Amit Sharma offer an FDA-approved device for incontinence that can be administered by non-professionals. The founders say it can help more than 100 million people globally. consuremedical.com

3

WINDMILL

Avijit Bansal and Ayesha Chaudhary launched the \$200 NeoBreathe, which helps newborns breathe by using a mobile neonatal resuscitation device. It is designed for frontline health workers and clinics. windmillhealth.weebly.com

4

CARDEA

Cardea Labs' ECG device, nicknamed the miRHYTHM, can monitor heart health via a smartphone. It can serve as an arrhythmia monitor, collecting data and producing a report for doctors, all for \$150. cardea-labs.com

5

SOHUM FOR ALL

Neeti Kailas and her husband Nitin Sisodia have built a device to screen babies for hearing impairment and loss. Launching in 2016, the Sohumi is a non-invasive, portable machine – easy to use in rural areas. sohumforall.com

A

QUACULTURE IS FAST BECOMING THE MAIN WAY THAT HUMANS

get their seafood fix. But fish aren't cattle; they don't turn passive when cooped up. So Trine Thorvaldsen is studying how to keep farmed fish from escaping. A health and safety expert, Thorvaldsen has been working for a Norwegian research institute, trying to figure out why her country loses around 200,000 captive salmon per year. (These escapees can wreak havoc on their wild brethren, polluting gene pools and spreading pathogens.) Her discovery: often it's not the fault of the fish-farming gear but the people using it. "There was one instance in which fish were being

pumped from one cage to another, but the workers didn't realise there was no net to keep them," Thorvaldsen says; by the time anyone noticed the mistake, 13,000 salmon had swum away. A more common error is for service boats to tear nets with their cranes or propellers.

Thorvaldsen believes that one key to reducing the number of "fishbreaks" is for the aquaculture industry to make its tools more user-friendly – she points out, for example, that crane operators need a better way to monitor how their joystick-controlled tools perform underwater. But Thorvaldsen also wants farm managers to ease up on workers. "We've had a lot of workers say, 'We are under a lot of pressure: we have to do things fast; we have to deliver the fish when the boat's there,'" Thorvaldsen says. Her changes might help fix all that – which should satisfy everyone but the fish. **Brendan I Koerner**

RECENT NOTABLE FISHBREAKS

Gulen, Norway: 120,000 salmon

A fire burned away part of the net.

Bantry Bay, Ireland: 230,000 salmon

Storm-damaged cages caused the biggest fishy jailbreak in Irish history.

Hinchinbrook Channel, Australia: 100,000 barramundi

Cyclone Yasi wrecked a fish farm.

Loch Earn, Scotland: 30,000 rainbow trout

The fish fled through net holes created by nibbling otters.

Lockdown at the fish farm

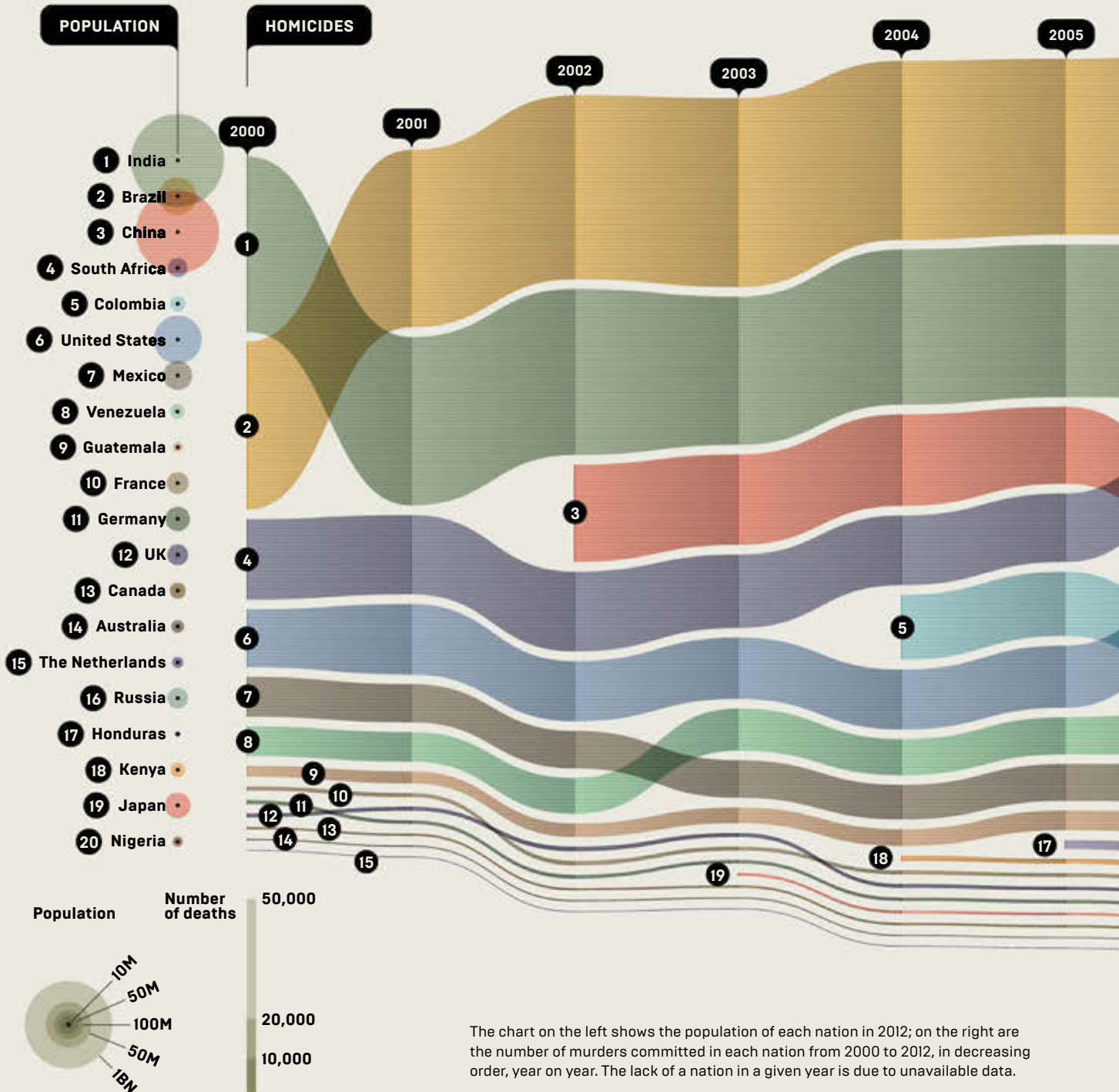


Murderous measurements

Where in the world are you most likely to meet an untimely end? The data suggests you avoid the global south...

THIS IS A SNAPSHOT OF THE WORLD'S MURDERS. "THE DATA SET IS the most thorough and comprehensive on homicide in the world – certainly on Latin America and the Caribbean," says Robert Muggah, research director of the Igarapé Institute, a Rio de Janeiro-based think tank that specialises in security and crime issues. The set includes 1,641 data points, including number and rate of homicides by country, victim age and gender, and the weapon used. "The primary source was the United Nations Office of Drugs and Crime's annual report, but we also collected data directly from national departments of statistics, police departments and other government entities," says Muggah. The data is being built into an interactive graphic that will allow people to estimate their own relative risk of

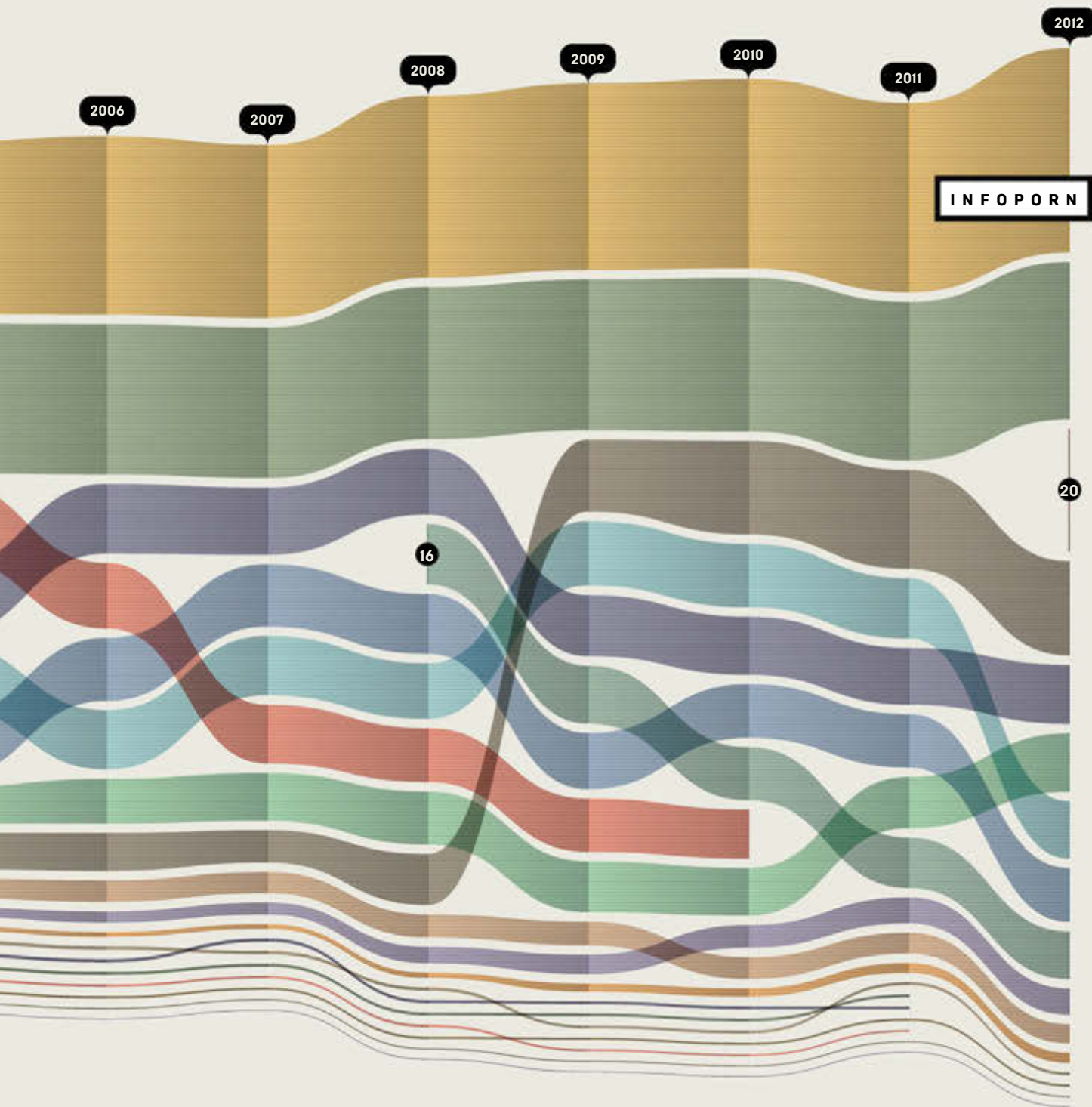
INFOGRAPHIC: VALERIO PELLEGRINI



being killed. “If you’re a 23-year-old Colombian woman, living in Bogota, the visualisation can tell you your risk of being murdered,” Muggah says.

Homicide rates are trending downwards in regions such as western Europe – dropping 40 per cent over the last 20 years – but it’s the opposite in the global south. “Latin America, the Caribbean and central and South Africa show an uptick,” says Muggah. “Latin America has nine per cent of the world’s population – and 31 per cent of its homicides.” Data shows a fifth of all murders occur in Mexico, Brazil, Colombia and South Africa; in Brazil, more than 56,000 people were murdered in 2012 alone. Honduras has the most violent city in the world – San Pedro Sula had a murder

rate of 187 per 100,000 in 2013 (London’s was 1.6). Still, there are positive exemplars in the region. “Medellin, considered one of the most dangerous cities in the world because of the Colombian cocaine trade, has dropped its homicide rate by almost 80 per cent since the 90s, thanks to data-driven policing,” says Muggah. “This shows that although we have a challenging situation, there are innovative ways to bring it down. We just need to use compelling tools.” *MV igarape.org.br*



PROPEL THE JET AGE INTO THE PAST

This aircraft wing runs on 18 propellers – and intends to turn the aviation industry electric. “With the normal integration of a propeller on each wing you get an overall efficiency of around 20 per cent,” says Mark Moore, principal investigator of the LEAPTech project at Nasa’s Langley Research Center in Virginia, where the wing is being developed. “We should be able to achieve 98 per cent.”

Despite improvements in electric motors in the past ten years, battery development hasn’t kept up, leaving electric planes such as the Airbus E-Fan constrained to less than an hour of flight time. Nasa’s solution, in collaboration with California companies Empirical Systems Aerospace and Joby Aviation, is to increase the aircraft’s

efficiency via distributed propulsion. “Unlike turbine engines, the power-to-weight ratio of electric remains good, no matter the size,” explains Moore. This means two propellers can be swapped for 18 smaller ones distributed across the wingspan, increasing lift at take-off and allowing for smaller wings that perform better in the air.

The 9.4-metre wing has other advantages. Electric motors allow for tighter control over rotation speed, so each can be set at a slightly different RPM, spreading the noise produced across multiple frequencies and reducing noise pollution.

Moore says the wing could be ready for commercial use on planes such as the 74-passenger ATR 72 within five years. “It has the potential to introduce renewable-based electricity for aviation,” he says. We hope it takes off.

Kathryn Nave [nasa.gov](#)



Nasa’s wind tunnels are fully booked, so the wing is being tested on the back of a truck

PHOTOGRAPHY: TOM TSCHIDA

WIRED	TIRED	EXPIRED
Every Frame a Painting	Kermode and Mayo	Narrative Cinema
Dash	1-Click	Leaving the house
Nemawashi	Holacracy	Coalition
Manual retweets	Quote tweets	Dot replies
Snowden Halloween costumes	Snowden statues	Snowden bots

A wobbly business plan

IN THIS NEW SERIES, INVESTEC PRIVATE BANKING EXPLORES THE PEOPLE BEHIND SOME OF THE UK'S MOST EXTRAORDINARY YOUNG COMPANIES

Bompas & Parr is no ordinary catering outfit. Various described as architectural foodsmiths, jellymongers and culinographers, cofounder Sam Bompas puts it best: "What we try to do is give people incredible experiences related to their everyday lives, but primarily linked to what's on the end of their fork."

Along with childhood friend Harry Parr, Bompas (*below*) has cooked steaks over lava, created an intoxicating gin and tonic fog, flooded the roof of London's Selfridges to make a boating lake and built a church organ that actively changes your sense of taste as it plays.

Formulated some eight years ago, the business had humble beginnings. "We wanted to do something really fun on the weekend," says Bompas, 31. "So we thought we'd get a stall selling

jelly at London's Borough Market. It was a hot summer and a lot of the food seemed rather stodgy. We thought we could do something delightful and wobbly."

The stall fell through, so they began experimenting – Parr, a trained architect, found he could make moulds for jelly from 3D-printed building models.

"Within a month of us starting with the jellies an article had been written saying we could make them in any shape and any size," says Bompas. "Someone called us up and asked for a jelly the size and shape of Warwick Castle – which was impossible. By the time they were off the phone we had agreed we'd make a 12-course, 4,000-calorie Victorian breakfast. We had to learn how to cook."

With that, Bompas & Parr began its transformation from extravagant jelly-

Objects found in Bompas & Parr's laboratory:

1. Gin and tonic mist.
2. A ceremonial human skull chalice.
3. Jelly architecture.
4. A glass orb used for future-gazing.
5. Fluorescent liquid.
6. Books for inspiration and research.

makers to Willy Wonka-style designers. But although the projects span New York, London and Dubai, its founders have always favoured fun over formality.

"We've never really had a business plan, but we've always had wild dreams," says Bompas. "The code we live by is drawn from William Blake: 'The road of excess leads to the palace of wisdom.' So in anything that we do – design, uniforms, food, the whole lot – we like to really push boundaries. And hopefully, along the way, we learn something."

CELEBRATING FEARLESS FOUNDERS

As a different type of private bank – one with a rich story that begins with our founders – Investec Private Banking celebrates fearless and exciting UK entrepreneurs. In partnership with our clients, we seek to write

tomorrow's success stories, motivated by a shared drive to succeed and an entrepreneurial spirit. We're not afraid to be out of the ordinary – just like Sam Bompas. Visit investec.co.uk/privatebanking



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Funding Circle

Samir is the founder of Funding Circle, the first site to use the peer-to-peer approach for business loans in the UK.



Alexa Clay
Author,
The Misfit Economy

Clay will offer innovation insights she learned from researching pirates, hackers and criminal gangs.



Peter Smith
CEO & cofounder,
Blockchain

Blockchain is trying to change the way the world transacts by building a safe and secure bitcoin wallet.



Celine Lazorthes
Founder & CEO,
Mangopay & Leetchi

Lazorthes founded money collection site Mangopay, as well as email-based money-transfer platform, Leetchi.



Stefan Thomas
CTO, **Ripple Labs**

The Ripple Protocol connects the world's financial systems to enable secure and instant payments in any currency.



Shivani Siroya
CEO & founder,
InVenture

At WIRED Money Shivani Siroya will present her model for disrupting credit scoring in emerging markets.

HEALTH | MONEY | 2015 | NEXT GEN | RETAIL

STARTUP STAGE PARTNER **BBVA VENTURES**

TICKETING PARTNER **Eventbrite**

The A250 (shown) can live-stream to an iPhone or iPad to help you set up your shot

FOCUS GROUP

PHASE ONE ALPA A-SERIES

The A-series combines ALPA's integrated lenses with Phase One's benchmark digital backs. Available as 50MP, 60MP and 80MP models, all three are fitted with a 35mm Rodenstock Alpar lens as standard. An ultra-wide 23mm and a 70mm all-rounder are also available for broadening or narrowing your photographic horizons.

From €36,000
phaseone.com

WORDS: HENRY FARRAR-HOCKLEY, PHOTOGRAPHY: STEPHEN LENTHALL



The BeoPlay A2 also comes in grey or black, and has a leather carry strap

BANG & OLUFSEN BEOPLAY A2

Bang & Olufsen is better known for its stylish high-end TVs and hi-fis, but this portable player still cuts a dash. There's a built-in battery and, usefully, a USB output so you can charge your phone. Beneath the plastic grille are two full-range drivers and tweeters, plus a pair of passive bass radiators. Each speaker/radiator pair faces in opposite directions – an attempt at 360° audio. As you might expect with a device this size, bass isn't huge, but is surprisingly punchy and the overall sound is well rounded. **7/10**
£299 beoplay.com

Size 25.6 x 14.2 x 4.4cm **Weight** 1.1kg
Speakers 2x 7.6cm full range; 2x 7.6cm passive bass radiators; 2x 1.9cm tweeters
Battery Li-ion
Power output 180W

BOWERS & WILKINS T7 WIRELESS

The first portable Bluetooth model from Bowers & Wilkins weighs under a kilo and comes with a rechargeable battery. Inside, a pair of full-range speakers, each powered by its own 12W class D amplifier, are ably assisted by a brace

of passive radiators to beef up the bass. The sound is clear with high levels of detail coming through, especially on acoustic tracks. Don't expect big bass, but what's there is well defined and quite undistorted. **8/10** £300 *bowers-wilkins.co.uk*

Size 21.0 x 11.4 x 5.4cm **Weight** 940g
Speakers 2x 5cm full range drivers; 2x passive bass radiators
Battery Li-ion **Power output** 24W
Inputs/outputs 1x aux out; micro USB



The honeycomb Micro Matrix helps dampen cabinet vibrations, which improves sound



Digital extra!
Download the WIRED app to read extended reviews of the speakers

HOW WE TESTED

Sound quality is paramount with a speaker, so WIRED carried out a series of audio tests comparing the performance of a wide range of music, from acoustic folk and jazz to power-heavy rock and dance tracks, as well as some ambient electronica. We also checked for set-up convenience, build quality and style.

The top surface of the SRS-X9 is a touch-sensitive control panel



SONY SRS-X9

Offering a neat compromise between a portable player and a stay-at-home system, the SRS-X9 is small enough to carry (you'll still need a plug socket, though) but large enough to deliver fulsome

sound. There's a pair of full-range speakers, with four tweeters plus an active subwoofer with by two passive radiators. For such a compact device, the sound is outstanding, with lots of detail. **9/10** £399 *sony.co.uk*

Size 43 x 13.3 x 12.5cm **Weight** 4.6kg
Speakers 2x full range drivers, 1x subwoofer **Power output** 154W
Inputs/outputs USB; Ethernet; LAN
Battery No **Wi-Fi network** Yes



Wireless wonders

WIRED puts Bluetooth speakers to the test, both at home and on the road



DALI KUBIK ONE

It might have the size and shape of a TV soundbar, but the DALI KUBIK ONE has ambitions as an all-you-need sound system. It's solidly built, with the base

made from a single block of aluminium. Around the back are two optical digital inputs, an analogue stereo input and a subwoofer output so you can get a bit more grunt,

though there's no HDMI input for your TV. The Bluetooth connection worked smoothly and the room-filling sound was effortlessly clear. **8/10** £799 *dalikubik.com*

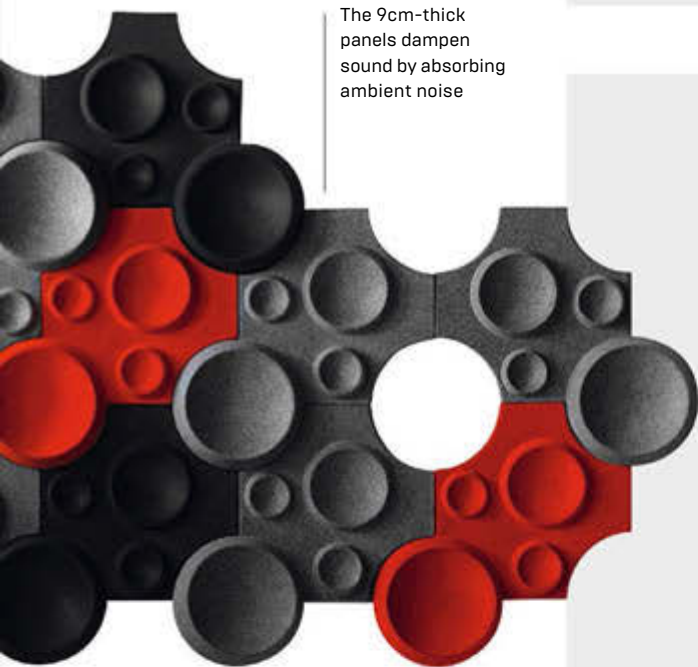
Size 162 x 980 x 102cm **Weight** 9.6kg **Speakers** 2x 13cm full range drivers; 2x soft dome tweeters **Battery** No **Power output** 100W
Inputs/outputs Sub out; analogue in; optical digital in; USB in

POET PANDORETTA

If you can place it in the middle of the room, as opposed to up against a wall, the impressively tight sound from the aluminium and oak Pandoretta is a 360° marvel. The underside has a plug for an AirPort Express Wi-Fi unit, plus one digital and two analogue connections for your TV and media players. **8/10** £2,740 *poetaudio.com*

Size 45 x 16 x 30cm **Weight** 10kg **Speakers** 1x Kevlar subwoofer; 2x bass/midrange speakers; 4x dome tweeters **Power output** 170W

TEST



The 9cm-thick panels dampen sound by absorbing ambient noise

WALL OF ROUND

JOHANSON DESIGN MOON

Johan Lindstén's sound-absorbing wall tiles feature patterns derived from lunar craters shaped by the impact of meteorites, asteroids and comets. The 90cm x 55cm tiles come in four standard shades: black, light

grey, anthracite and off-white, plus an additional 48 colours if bought with a Europost felt upper. The foam-backed, recycled compressed polyester fibre panels interlock to create a striking geometric landscape. From £108 johanson.design.com



STANDING ORDER

WILLIAM MCDONALD STACKING LAMP

Inspired by a childhood toy, this space-saving, 185cm-tall design is adaptable so you can stack its four components in a sequence of your choosing.

A variety of brightly coloured steel lampshades, spacers and coat hooks are available to create anything from a vertical wardrobe to a column of up- and down-lighters. \$390 willmcdonald.ca

ADJUSTABLE CARRY-ON

HEIMPLANET MONOLITH DAYPACK

It's not just this 22-litre ballistic nylon bag's ability to convert effortlessly from a backpack to a messenger that appeals, nor its expandable, front-mounted straps for transporting bulkier items. It is rather the flexible nature of its MOLLE webbing system, which permits a multitude of storage pouches to be attached at whim, each one reinforced to show all your to-go essentials. £170 heimplanet.com



Three bags in one: backpack; carrier for bulky items; and messenger



SCREEN SAVER

HERMAN MILLER KIVO

Drawing on particle physics, this flexible geodesic structure provides a little welcome privacy to open-plan working and living spaces.

German designer Alexander Lorenz's free-standing system offers more than 50 room-dividing configurations. It comprises simple, three-dimensional magnetic tiles made from either pure new wool or

a polyester and viscose blend, which attach to a skeletal steel frame that can be adjusted using a single Allen key. £tbc hermanmiller.co.uk/kivo

Shape shifters

Five products that fold, adapt and combine super-fast

CLEVER KAYAK

KLEPPER BACKYAK

Neatly folding away into matching 10kg backpacks, the BACKYAK is a highly configurable personal leisure craft capable of being a three-person 5.4-metre kayak, or two 2.7-metre single-occupant ones. It can also become a mobile bathing platform, a twin-hull catamaran and – with an optional snow kit – a fully equipped toboggan. Other extras include an e-motor and inflatable sponsons for additional ballast. From €5,000 backyak.de

FETISH

By rearranging the hull parts, the BACKYAK can be reconfigured into other modes



Add elevated sled runners for snow



Add a trampoline, sail and rudder



Cap the ends for two mini-kayaks

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TICKETING PARTNER

Wearable tech

WIRED risks a nasty chill to test the latest insulated jackets

ARC'TERYX ARGUS JACKET FEATURING POLARTEC ALPHA

Despite feeling thinner than the other jackets – and not being insulated under the arms or across the back – the Argus offers body warmth without bulk. Perfect for activities where you need full range of movement, the thin Polartec Alpha insulation is extremely breathable and dries quickly, while the nylon outer is shower resistant. Surprisingly, this jacket was the heaviest on test, at 385g. But combine the



TEST

superb comfort, a body-hugging fit and stash pockets for convenience, and there's more to this jacket than its skinny proportions suggest. **8/10**
£120 arcteryx.com

Insulation 49g/m²
Polartec Alpha
Weight 385g

▲ Climber Amanda Putt, at "Too short to Mention" (6a) at Eridge Green Rocks, East Sussex, shares her technical-jacket requirements: 1 / Breathability: "Climbing isn't a gentle activity." 2 / Movement range: "You can't climb if you feel restricted." 3 / Looks: "It needs to look cool, especially when not up a mountain."



THE NORTH FACE THERMOBALL JACKET INSULATED BY PRIMALOFT

This undeniably accomplished mid-layer jacket was a good all-rounder in the cold test, despite having minimal

insulation. The tight puffs trap the heat, especially around the arms and where material doubles-up,

but the seams do create cold bridges more than the other jackets. It's also the least attractive design on show, looking more high street than Himalayas. And although the jacket packs down into a pocket, that roomy, heat-trapping fit does feel bulky, despite being extremely light. **6/10** *£150 thenorthface.co.uk*



Insulation 33g/m²
Weight 330g



BLACK DIAMOND ACCESS LT HYBRID HOODY FEATURING PRIMALOFT GOLD

Thin enough to be worn beneath a bulkier jacket, the LT Hybrid offers plenty of protection on

its own. It's not overstuffed and the Primaloft Gold provides admirable warmth, but WIRED's poor

wrists still got a bit chilly. It's not quite as cosy as the Arc'teryx, but it is lighter, and packs down into the chest pocket. It won't handle much beyond a light shower, but the ripstop shell dries quickly and maintains breathability. **8/10** *£180 eu.blackdiamondequipment.com*

Insulation 40g/m²
Primaloft Gold
Weight 370g

TEST



ISAORA treats its down filling to make it thermally reactive

ISAORA MICROLIGHT IR DOWN WITH CELLIANT THERMOWDOWN INSULATION

Despite having the least amount of insulation and the lightest weight, ISAORA's good-looking jacket performed well in the cold test – although there were noticeable

cool spots along the stitching. In everyday use it was the hottest jacket to wear for long periods and it lacked breathability. It is reassuringly water resistant,

though, despite being down-filled, but even with its feather-light build, it doesn't pack very small. **6/10** \$225 isaora.com

Insulation 27g/m²
Weight 324g

HOW WE TESTED

Armed with the Seek Thermal camera and a Sony Xperia Z2 smartphone, WIRED took five of the latest mid-layer insulated jackets along to London's perpetually chilly ICEBAR (icebarlondon.com). After ten minutes acclimatising in just a T-shirt – the ICEBAR is kept at a constant -5°C – WIRED wore each jacket and took thermal pictures at the beginning of the test and after four minutes. To establish a consistent baseline, WIRED cooled down for four minutes between wearing the mid-layer jackets, each boasting hi-tech, high-performance insulation.

MAPPED: ESCAPING HEAT

The Seek Thermal is a simple plug-in thermal-imaging camera for Android and iOS smartphones. It takes 206 x 156-pixel thermal pictures – hot surfaces, such as the faces below, are light; cooler ones, like insulated areas, are dark. \$249.00 thermal.com



Arc'teryx

Black Diamond

Patagonia

Isaora

The North Face

PATAGONIA NANO-AIR WITH FULLRANGE INSULATION

The thickest jacket in our group, the Nano-Air's super-soft outer shell is stretchy, cosy and surprisingly water resistant. It also packs in more insulation density, but had both the best and worst cold-test – its unprecedented midriff insulation

was marred by oddly heat-leaking shoulders. The extra bulk doesn't hamper manoeuvrability, and there's plenty of protection for spring skiing, camping or chilly walks. **7/10** £180 patagonia.com

Insulation 60g/m²
Weight 354g



The rolled seams make the Patagonia jacket especially comfy around the neck





CUSTOMISABLE AUDIO

AIAIAI TMA-2 MODULAR

The Copenhagen studio's second generation of professional headphones allows you to create a personalised headset. Simply match your specific listening habits to its fully-interchangeable framework

of 40mm speaker drivers, headbands, ear pads and cables. As well as providing 360 different configuration possibilities, the range is also available as four pre-configured styles (from an all-rounder to a DJ-centric design) for assembly-free convenience.
From £100 aiaiai.dk



Speakers



Cables



The headband is made of TR90 polyamide and is super flexible

Bonobo, MistaJam and Ed Banger have all pre-configured pairs of headphones

BOLT UPRIGHT
MECCANO HOME

Take a much-loved childhood construction toy, a contemporary Gallic interiors brand and a team of designers and engineers and you get this highly adaptable furniture range comprising life-

sized Meccano pieces. The flat-pack system comes in a range of indoor, outdoor and child-proportioned designs including benches, lamps and tables – each built from a core of 21 basic parts. The signature nut-and-bolt fasteners are available in eight colours to create subtle contrasts to the two-tone finishes. From €149 meccanohome.com

WIRED
LOVES

Individual plates, struts and legs can be added to modify furniture dimensions



CLOUD HAILER

RICHARD CLARKSON TINY CLOUD

This little fluffy cloud is, in fact, a remote-controlled light with music-reactive colour-changing LEDs and a Bluetooth speaker. As well as pulsing in time to the music, the 200mm formation can also provide a *bona fide* storm sequence using the identical randomised lightning pattern to Hurricane Sandy. It comes to life via a regular light socket, wall-based power-point or standard USB. From \$480 richardclarkson.com



LISTEN UP

RESOUND LINX2

This smart hearing aid is packed with spatial audio-enhancing tech. It's fitted with an ergonomic SureFit receiver for optimum comfort and sound quality, and is treated with its proprietary iSolate nanotech coating to repel dust, moisture and corrosive substances such as sweat. It can also directly stream audio content in stereo from your iOS devices, and the accompanying app lets you adjust volume, treble and bass directly from your phone or tablet. From \$1,600 resound.com

Minor marvels

Diminutive technology that's big on specification

ON THE BUTTON

INTEL CURIE

This low-power module was conceived by Intel as a self-sufficient hardware option for a wide range of wearable tech designs, from fitness trackers

to connected jewellery. Driven by the Intel's first system-on-a-chip – the 32-bit Quark SE – it contains the now-standard smart-device array of six-axis sensor, accelerometer and gyroscope,

alongside 384KB of flash memory and Bluetooth, all in a footprint the diameter of a button. It also ships with its own simple real-time OS. [\\$tbc.intel.com](http://$tbc.intel.com)



FETISH

BRAIN BOX

WONDERCUBE

Measuring a mere 25.4mm, this low-profile, rugged ABS key-fob is billed as the world's smallest all-in-one mobile companion. The Indiegogo-funded device offers eight handy tools for smartphone users, from USB syncing (there's a choice of Apple Lightning and micro USB adaptors) to quick charges via a 9V



battery port, a micro-SD slot for freeing up storage space to a built-in LED torch. The 20g hub needs no extra cables due to an integrated, thermoplastic USB cord. From \$49 thewondercube.com

TINY CAM

MARSHALL ELECTRONICS CV500-MB-2



Shoehorning a 2.2MP Sony Exmor CMOS sensor into a 36mm-wide video camera is no mean feat – especially when the camcorder in question is a heavy duty, HD broadcast-ready model. Tailored

to function in myriad scenarios, it can handle fly-on-the-wall documentaries to live sports. Digital "fog" removal, pixel correction, noise reduction, auto day/night

switching and extreme low-light sensitivity are included as standard, and the feed is output via an HD-SDI port. The camera is also compatible with a dozen Marshall HD lenses. From \$599 lcldracks.com

IS

an Francisco's technology scene and its golf courses are inexorably entwined. For decades company executives have taken time on the links to relax, network, hash out deals and seek advice.

On April 27, 2015, the two worlds became closer still as Swiss *Haute Horlogerie* brand Audemars Piguet hosted its fourth International Golf Invitational at Half Moon Bay Golf Links. Following the competition – which saw Audemars Piguet clients play alongside golf champions of the past, present and future – a debate session was held to discuss the interplay between golf, technology and business.

Chaired by Mark Rolfing, golf analyst and commentator, the panel comprised François-Henry Bennahmias, CEO of Audemars Piguet; Patrick Rahme, cofounder and CEO of golf-dedicated social platform All Square Golf; and Ian Poulter, owner of the clothing line IJP Design and golfer extraordinaire.

Early in the discussion, Bennahmias suggested that his background in golf – himself a former pro – led to his success in the fashion business.

"There are a lot of things I've learned through golf and with golf that are helping me with the way I run the business today," he says. "The first thing is never give up. If you make a bogey or double bogey, it's not over. Another thing is to see it first before you do it... you have to be able to see exactly where you want to go to be able to do it."

For Poulter, technology – specifically social media – has changed his relationship with golf and his business.

"I love interacting with the fans. For me to reach a diverse group of people



Business and bunkers

IN APRIL, AUDEMARS PIGUET COMBINED GOLF, TECHNOLOGY AND BUSINESS AT ITS FOURTH INTERNATIONAL GOLF INVITATIONAL

all over the world – 1.8 million people – if I think about that it's crazy," he says. "More importantly I think it's brand-building – people know who I am, I'm very honest... and as a whole it helps my business."

Patrick Rahme has actually built a social networking platform for golf. "We see our

platform as an extension of the clubhouse, connecting golfers before their round and allowing them to share their experiences afterwards," he explains.

Whether you network on the green or online, be sure to check out more from the debate at wired.co.uk/promotions/apgolf



WATCH THE BIRDIE

The Audemars Piguet Golf Invitational gathered heroes of the sport's past, present and future.

Those teeing off by the Pacific Ocean included 2014 FedExCup winner Billy Horschel, plus

seven members of the Audemars Piguet Golf Ambassadors team. Among them six-time Major champion Sir Nick Faldo; match play legend Ian Poulter; the larger than life Miguel Ángel Jiménez; 2010 Open winner at St Andrews, Louis Oosthuizen; plus two 25-year-old future stars – Victor Dubuisson and Bud Cauley. Finally, Audemars Piguet welcomed Bernd Wiesberger – the first Austrian to compete in the Majors – to the team.



WORN ON THE WRISTS OF CHAMPIONS

1



OFFSHORE 42MM CHRONOGRAPH

This self-winding chronograph displays the date at 3 o'clock and seconds at 12 o'clock. Waterproof to 100 metres, it

features a crocodile strap and the AP signature case, with a chunky octagonal bezel bearing eight hexagonal screws.

2



TOURBILLON CONCEPT GMT

This hand-wound tourbillon features a GMT function to keep you synced with more than one time zone, while a titanium case

cradles an open-worked dial. A white strap and ceramic bezel, crown and pushpiece completes the crisp, modern look.

3



TOURBILLON CHRONOGRAPH

This blue Tourbillon Chronograph has a 950-grade platinum case and a black ceramic screw-locked crown. It's finished

with glare-proof sapphire crystal and is open-worked at 6, 9 and 12 o'clock. A blue rubber bracelet secures it to the wrist.

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IDEAS BANK

SAMUEL GREENGARD

Data oversupply is unplugging our brains

T

here's a paradox associated with technology: the more connected we get, the less in touch with the physical world we become. For better or worse – and it can sometimes be both – technology adds an abstraction layer between the natural world and a person. The Polynesians and Vikings sailed across entire oceans in small boats without GPS or maps. Now, most people can't read a map and many have trouble following road signs. Some people even turn the wrong way down a one-way street or drive off a cliff simply because the navigation system told them to do so.

The more data we attempt to assimilate, the deeper we wade into this abyss. Activity trackers tell us when we have hit our daily activity and calorie goals, timers and automated cooking systems alert us when our food is done and computers do our calculations – and increasingly our thinking – for us. Every step, spoonful and click leads us down a distinctly different path than if we

watched the food brown, felt when our stomachs are full or tuned into our breathing or fatigue level and used these as a guide for exercise.

The irony? We're not necessarily better runners, drivers, sailors and chefs – and, at an aggregate level, we're certainly not any fitter or healthier than our grandparents. In fact, all evidence points to the contrary. Increasingly, we depend on data points instead of senses and perceptions to define what is going on around, among and inside us. Within this framework, a greater number of data points often translates into a lack of knowledge and greater confusion.

The evidence is everywhere. We now wade through food-ingredient lists that require an advanced chemistry degree to understand. This makes it much easier for companies and marketers to feed off the confusion and concoct products, slogans and terms that sound great but don't deliver nutritional value. Similarly, the overload of data – particularly research about health and wellness – spawns ever-growing confusion



Samuel Greengard is a business and technology writer. He wrote *The Internet of Things* (The MIT Press)

about what's beneficial and what isn't so good. Amid all the confusion, we throw up our hands and give up.

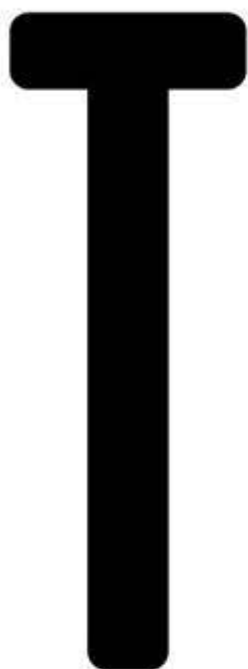
Sometimes, the solution also becomes a new problem. Rangers and rescue teams report that the number of people heading into the wilderness with inadequate equipment, food and supplies has steadily risen since the introduction of the mobile phone. When people get into trouble, they simply call for help – if the phone can grab a signal. Some have also posited that we worry less about diet and overall wellness because we believe that technology will somehow save us. Diabetes or high blood pressure? There's a pill for that. Clogged artery or bad organ? There's a procedure for that. Soon, we'll have 3D-printed organs to replace the no-longer-functioning natural organ.

The ultimate question is whether trillions of connected devices that can peer into every nook and cranny – and see between the spaces that are invisible to the human eye – will actually create greater insight and knowledge or further disassociate humans from their planet. At a certain point, when increasingly smart devices and machines are assigned tasks that humans handle, we are at risk of losing knowledge about the most basic things: how to grow food, how to travel from A to B, and how to build shelter and keep ourselves warm. As long as we have machines, we're fine. But if they go away, it could be the start of a long, cold winter.



JONATHON KEATS

Take animal testing from the lab... to your pet dog



he fountain of youth is going to the dogs. At least that's true in Seattle, where biogerontologists Matt Kaeberlein and Daniel Promislow at the University of Washington have asked local dog owners to lend their pets to test an experimental anti-ageing drug. More than 1,000 pooches were offered and 32 were chosen for the study, set to begin this spring.

The drug they'll be taking, rapamycin, wasn't originally intended to extend canine longevity – it's often used as an immunosuppressant, typically prescribed to people after an organ transplant. But rapamycin also blocks a gene called mTOR, which causes cells to age and break down more rapidly. Several years ago, when scientists fed rapamycin to mice, they found that the rodents lived about ten per cent longer than control groups. That evoked visions of (human) retirees sipping rapamycin milkshakes, an idea drug companies would already be fast-tracking if rapamycin were still protected

intellectual property. But it is off-patent, taking huge profits off the table. Call in the K9 squad! Millions of dog owners – including Kaeberlein and Promislow, who own a German shepherd, a keeshond, a Weimaraner and a chow mix between them, although none of them are eligible for the study – are eager to give their pets an extra few years. Since most human masters can administer meds and manage some daily monitoring, researchers can crowdsource a lot of the data collection. Furthermore, the dog lifespan is so short (awww) that they can provide relatively rapid returns on research.

That's a juicy bone for dogs and their best friends, but what's really at stake is nothing less than a revolution in drug testing. Kaeberlein and Promislow have effectively unleashed a practical way to research new human uses for out-of-patent drugs. Pets can provide a cheap alternative to pricey and chancy human clinical tests, key when you're dealing with a drug that might not be especially profitable in the first place.

It's easy to extend the idea beyond rapamycin. Testing experimental drugs on pets is a potential new template for human medical research: such experiments would be less expensive than testing drugs on lab animals but still statistically valid, since the greater number of test subjects would override the quirks of home-style observation. And dogs are genetically diverse, another plus. It would also be more humane, since dogs are more frolicsome at home than in a kennel. Making drug studies more affordable would allow pharmaceutical companies to profit from old or unpatentable drugs. Researchers could test other potential anti-ageing chemicals on dogs with the hope that they could one day invigorate people.

And researchers could enlist pets to investigate more targeted benefits of rapamycin as a treatment for



specific human ailments. The drug can reverse cardiomyopathy in mice; as a step toward helping people, Doberman pinschers – a breed that's naturally susceptible to a version of the disease – could serve as guinea pigs, although a study like this might require more assistance from a vet, as the average pet owner won't have the kit to administer a slate of complex cardiovascular tests.)

Dogs have other opportunities to give old drugs new tricks: growing evidence suggests that the out-of-patent diabetes medicine metformin may have unexpected benefits for cancer patients. For example, diabetic men on metformin are less likely to die of prostate cancer than those taking other diabetes drugs. Those studies are retrospective, meaning that they analyse pre-existing data. A metformin study on golden retrievers – a breed prone to cancer – could provide clinical data crucial to future human prescription.

Kaeberlein and Promislow are wary about treating people's pet dogs as lab rats. Both insist that their motivation is to improve dogs' lives; human benefits come second. Their respect for Fido's wellbeing is laudable, but that's nothing a clinical review board can't handle. What would be truly irresponsible would be to lose the chance to help people.

Dogs share our lives. They live in the same environments as we do and they're exposed to many of the factors that most affect our health – from bad food to second-hand smoke. Testing drugs on them is a realistic way to try out pharmaceuticals that might otherwise get ignored. After all, if our dogs start living forever, we're going to need to be around to walk them.



Jonathon Keats
is a US WIRED
correspondent

When it comes to pinning down new terms in tech, the *Oxford English Dictionary* (OED) moves at glacial speed compared to Wikipedia. But once the OED casts its judgment, people listen. This quarter, the OED finally released its definition of the “sharing economy”: “(n.): an economic system in which assets or services are shared between private individuals, either for free or for a fee, typically by means of the internet”.

However, a rising chorus of critics, including the *Harvard Business Review*, has queried the focus on “sharing”. For them, it is rather about providing access via a simple rental model. At least the rental model of Airbnb involves people “sharing” access to the same assets. But the “sharing” economy also covers the sale of goods, through sites such as eBay and Etsy. Here, “sharing” carries little of its usual sense of joint, often equal, use or ownership.

Other critics such as John Harvey, a researcher at the University of Nottingham, go further. He believes the term is not just misleading but downright dangerous: an attempt to put a moral gloss on businesses that are as unsentimental as any other. The meaning of sharing, says Harvey, should be “wrestled back from the jaws of those using it to profiteer”.

Other terms – the collaborative economy, the peer economy – have been suggested. But the genie is out of the bottle. Like a company with an awkward name that is far down the

ALEX STEPHANY

Let's own that phrase 'the sharing economy'

road of brand awareness, the sharing economy may have to make do with an imperfect name. Even if a “rebrand” were possible, new names could fracture a growing movement of people who have no problem with the term, and who are building something that is – for the most part – a social and economic good.

But nor is the term devoid of merit. While ownership may not be shared, the sharing economy is reducing our need to own assets by giving us access to other people's. A study from UC Berkeley found that the average shared car takes between nine and 13 cars off the road. Now that we can also Uber, we will soon need fewer

underused cars that, according to the RAC, are parked for 96.5 per cent of their lives. Allowing us to make more efficient use of shared assets will help to deleverage the global economy since assets like cars are often bought on finance. The capital will be used elsewhere, creating employment – such as among the million-plus micro-entrepreneurs with Etsy stores.

By 2025, accountancy giant PwC expects the sharing economy to be worth \$335 billion (£225bn). That's small in macro terms, but its impact will be felt chiefly in the social capital it creates. Countless new relationships are formed every day via platforms that enable people to get goods and services from each other. More than 15 million people have shared homes on Airbnb. Even more remarkably, BlaBlaCar transports more than two million people each month using the excess capacity in people's cars: twice the number who travel by Eurostar.

The sharing economy is an odd term, but then it is an odd economy whose chief impact will be felt outside the world of GDP and stock tickers.



Alex Stephany
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is CEO of JustPark
and author of
*The Business of
Sharing* (Palgrave
Macmillan)

CLIVE THOMPSON

Boredom is interesting



Clive Thompson
writes for US
WIRED and is
the author of
*Smarter Than
You Think:
How Technology
is Changing
Our Minds for
the Better*
(William Collins)

Yelena, the young wife in Chekhov's 1897 play *Uncle Vanya*, has a complaint. “I'm dying of boredom. I don't know what to do.” Of course, today Yelena would pull out her phone and find BuzzFeed or Twitter or *Clash of Clans*. If you have a planet's worth of entertainment in your pocket, it's easy to stave off ennui.

Unless it turns out ennui is good for us. What if boredom is meaningful and propels us to deeper thoughtfulness or creativity? That's the suggestion of two recent studies. In one, researchers asked subjects to do something boring,

like copying out numbers from a phone book, and then take tests of creative thinking, such as devising uses for a pair of cups. The result? Bored subjects came up with more ideas than a non-bored control group, and their ideas were often more creative. In a second study, subjects who took an “associative thought” word test came up with more answers when they'd been forced to watch a screensaver.

Boredom might spark creativity because a restless mind hungers for stimulation. “Boredom becomes a seeking state,” says Texas A&M University psychologist Heather Lench. “What you're doing now is not

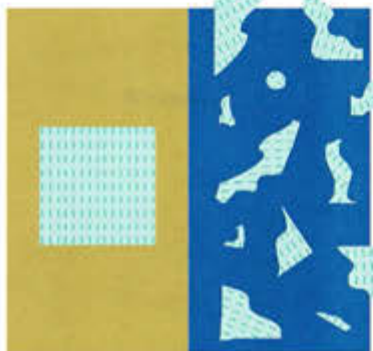
satisfying. So you're seeking, you're engaged." A bored mind moves into a "daydreaming" state, says Sandi Mann, the psychologist at the University of Central Lancashire who ran the test with the cups. Parents say that kids with "nothing to do" will eventually invent some weird, fun game – with a box, a light switch, whatever. Philosophers have intuited this for centuries; Kierkegaard described boredom as a prequel to creation: "The gods were bored; therefore they created human beings."

The problem is that these days we don't wrestle with these slow moments – we eliminate them. "We try to extinguish every moment of boredom with mobile devices," Mann says. This might relieve us temporarily, but it shuts down deeper thinking. Noodling on your phone is "like eating junk food," she claims.

So here's an idea: instead of fleeing boredom, lean into it. Sometimes, anyway. Mann has found she gets some of her best thinking done when she's commuting by car and can't self-distract with her phone. When novelists talk about using Freedom, the software that shuts down one's internet connection, they often say it's to avoid distraction. But I suspect it's also about enforcing a level of useful, productive monotony.

There is also bad boredom. The good type motivates you to see what can come of it: "fructifying boredom", as the philosopher Bertrand Russell called it. The bad type, in contrast, tires you, makes you feel like you can't be bothered to do anything. (It has a name, too: lethargic boredom.)

Our modern task, then, is learning to distinguish the useful dullness from the stultifying type. Boredom, it turns out may be super-interesting



TIM WEBBER



Tim Webber is chief creative officer at London-based VFX company Framestore (WIRED 01.15)

Virtual vs augmented: rival realities square up

Our virtual and real worlds are colliding. It's something that our favourite harbinger of digital dystopia, Charlie Brooker, predicted a couple of years ago with his ominous *Black Mirror* tale

of Waldo: the interactive bear that, despite being a cartoon, manages to disrupt politics on a global scale.

But real-time interactive CG creatures such as Waldo don't just exist in fictional stories. For some time, people have been creating this type of character for brand campaigns, with GEICO's walking, talking CG gecko a case in point – it was even "interviewed" by Chelsea Clinton for NBC. And when Michael Jackson can come back from the dead as a hologram for a *Billboard* Music Awards performance, it's clear that not only brands commercially benefit from visceral renderings of characters dreamt-up in computers.

The merging of computer-born effects into our physical real world is an area about which artists such as Chris Milk and Marshmallow Laser Feast are rightly curious. And it's becoming clear a lot of artistic potential can be gained from exploring the synthesis of real and digital spaces.

Perhaps the most obvious example of computerised characters escaping the confines of their screens to intersect with our real lives lies in the virtual reality (VR) renaissance (see feature on p120). If we thought a gecko being interviewed in real time was impressive, VR exponentially elevates real and virtual interaction.

VR's second coming seemed to begin when Oculus Rift became a household name during the 2014 Consumer Electronics Show. In the short period since, it has generated unparalleled excitement. Similarly, its potential as a gaming, artistic, marketing, warfare and communications medium is being thoroughly interrogated by a wide variety of people, businesses and interests. With Oculus hiring Pixar



artists and launching Story Studio, a production unit, we received concrete evidence that VR will begin to seep into the film industry. With such a frenzy of activity across sectors, mass adoption of VR seems inevitable. But the relatively quiet rise of glasses-based augmented reality (AR) – whereby wearable technology inserts digital imagery into our surroundings – will arguably have even more impact. AR will also jumble up our real and digital spheres, but in an even more convincing way than VR. Why? Because with AR you stay in the real world.

When Google decided to stop selling its original Google Glass, it was a sure sign that AR had already developed well beyond its initial humble aims. Even Microsoft, with its new HoloLens goggles that blend 3D virtual worlds with our own, has managed to leapfrog the "glasshole" accessory. Then there's the tantalisingly enigmatic Magic Leap, which – if rumours are to be believed – promises all sorts of AR experiences.

So it's clear there's a fused future just around the corner, one where we'll be able to walk down the road and interact with metaphysical entities. But how will this progress in the blurring of the real and virtual affect society? How can we function without a shared reality? We don't know but we can say it's another step in the AI march towards merging man and machine. But that's a prophecy best left to Charlie Brooker.



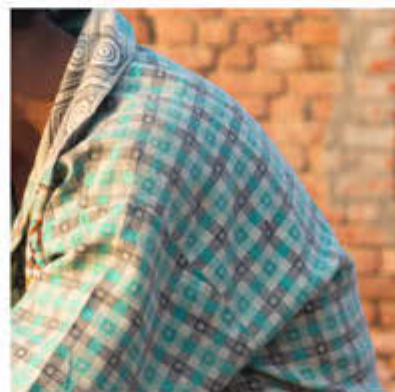
“Only technology can give everyone the opportunity to learn.”

SUGATA MITRA,
SCHOOL IN THE CLOUD

MAKETECHHUMAN

THERE'S NO TIME LIKE THE PRESENT TO SHAPE THE FUTURE.

NOKIA AND WIRED took the maketechhuman conversation to Sugata Mitra, Professor of Educational Technology, Newcastle University in the UK. Mitra is best known for his SOLE (Self-Organized Learning Environments) experiments in India, which proved that kids will teach themselves—and each other—if only given access to computers. Mitra has since started School in the Cloud, an online learning platform that puts Mitra's theory into global practice. “Our minds are our greatest strength and our gravest danger,” says Mitra. “We need to understand the mind, the brain and consciousness. We need to find out not just how we learn, but why we learn. In that lies our purpose.”



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The finished slide will be able to scare 180 people per hour

27.5m

Free fall starts here

Vertical drop for 27 metres

At this point you reach 80kph and up to 6 g of force



DROP IN ANY TIME

This is Sky Caliber: the world's first safe vertical-loop water slide, according to its creators Skyturtle Technologies. Gravity-defying loops have traditionally been seen as too risky, but Canadian designer Lance Fisher, 36, came up with a solution in his sleep. "I realised that being in a vehicle inside the slide lets

you do a vertical drop safely."

After a year of virtual 3D simulations, 50 raft designs – including a terrifying head-first option – were discarded. "We wanted to make the raft open, like a skeleton frame," says Fisher. Riders are fastened into the capsule with a padded harness, and the mesh outer layer allows them to be soaked by 4,500 litres of water coming through the tube each minute. The whole loop takes about

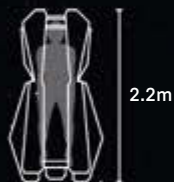
eight seconds and begins with a 27-metre drop (including 14 metres of free fall) to make sure the aluminium raft reaches the 80kph needed to make it over the loop. The tunnel is rifled inside to help the capsule to spin on its axis, like a bullet.

Fisher himself was first to test the prototype. "The feeling of weightlessness

was intense, extreme, but awesome," he says. The completed ride is planned to open at New Jersey's Action Park in 2016.

Not extreme enough? Don't worry, Fisher is working on increasing the height of the drop. "We want to break the speed record for a water slide," he says. "Being inside a capsule allows us to do things most water slides can't do."

Sophia Epstein
skyturtletech.com



The M50-URV raft is an open design that allows the capsule to spin 360° as it travels down

BROCHURE
PRICE:
£1 MILLION

9m-long loop

S



Carol Danvers is about to go intergalactic. In 2018, she will become the first female hero to headline a Marvel movie, *Captain Marvel*. But in the meantime, she has become a lightning rod for fans clamouring for more diversity in comics.

Danvers debuted in 1968, supporting the original (male) Captain Marvel. After a stint as Ms. Marvel, Danvers took on the deceased captain's mantle in 2012. Under writer Kelly Sue DeConnick, 44, fans calling themselves the Carol Corps have rallied around the hero.

"We knew something important was

about to happen," says Marvel comic-book editor Sana Amanat. Initial anger towards Danvers' promotion was quickly drowned out by positivity.

"The conventions were incredible – women and men dressed as the new Captain Marvel made us realise that this was bigger than the comic series."

This enthusiasm inspired *Captain Marvel and the Carol Corps*, out June 9, a mini-series co-written by DeConnick and Kelly Thompson. The comic is part of Marvel's Secret Wars event, a crossover storyline that promises to reshape the comics' multiverse.

Even bigger is the part the Carol Corps are playing in improving representation

PUTTING THE HER IN HERO

MARVEL'S NEW FEMALE LEAD IS ON A MISSION

in comic culture. "There's been progress," says Amanat, "but the real progress happens when we have a balance of men, women and minorities on the main stage – and no one bats an eyelash. That's when we'll be victorious."

Matt Kamen

Right: Carol Danvers. Top: early sketches from Captain Marvel and the Carol Corps



teven Spielberg's *Jurassic Park* isn't just a monster-movie classic, it marked a huge leap in visual effects on its 1993 release. "That film was a step forward that I'm not sure we've seen before or since," says *Jurassic World* director Colin Trevorrow. But for the franchise's fourth instalment, the crew wanted to push the visuals to even greater heights.

Jurassic World picks up 22 years after the original, with the park reopened by the Masrani Global corporation. With guests bored of T. rex and velociraptors, the park is now filled with previously unseen species, such as mesosaurus – and a new, genetically modified dinosaur, Indominus rex. To create the creatures, the crew turned to the Oscar-winning team behind the original film: animatronics company Legacy Effects – previously Stan Winston Studios – and Industrial Light and Magic (ILM).

In addition to custom-built animatronics and CGI, the film uses techniques new to the series: motion-captured velociraptors and digitally enhanced prosthetics. "Legacy built us fully textured maquettes, over which ILM would layer skin and eyes," says Trevorrow, 38. "The effect is extraordinary: humans are touching and acting off them, but there is an ability for the skin to breathe and eyes to move in a way that animatronics can't."

But despite the progress in CGI techniques since 1993, certain scenes were still done using old-fashioned, hand-built animatronics. "There is a scene where [actors] Chris Pratt and Bryce Dallas Howard come across a dying apatosaurus," says Trevorrow. "We had a team of puppeteers using every tiny motor in this robot's face. They drew a beautiful performance out of the actors – we couldn't have done it with a computer." But ultimately, he says, the CGI vs practical effects debate is meaningless. "If you stop thinking about the fact these are visual effects or robots, then we've won."

OF-W *Jurassic World* is released on June 12

Colin Trevorrow
with a prosthetic
Jurassic World
velociraptor

To hatch a predator

HOW DIRECTOR COLIN TREVORROW EMBRACED OLD-SCHOOL EFFECTS FOR JURASSIC WORLD



DINOS EVOLVE

HOW JURASSIC WORLD BUILDS ON THE FRANCHISE'S VISUAL TRICKERY



JURASSIC PARK (1993)

A mix of puppetry, animatronics and CGI led to an Oscar for Best Visual Effects.



JURASSIC PARK III (2001)

Advances in rendering led to more realistic dinos (shame about the script).



JURASSIC WORLD (2015)

Digital maquettes combine with motion capture and powerful CGI capabilities.

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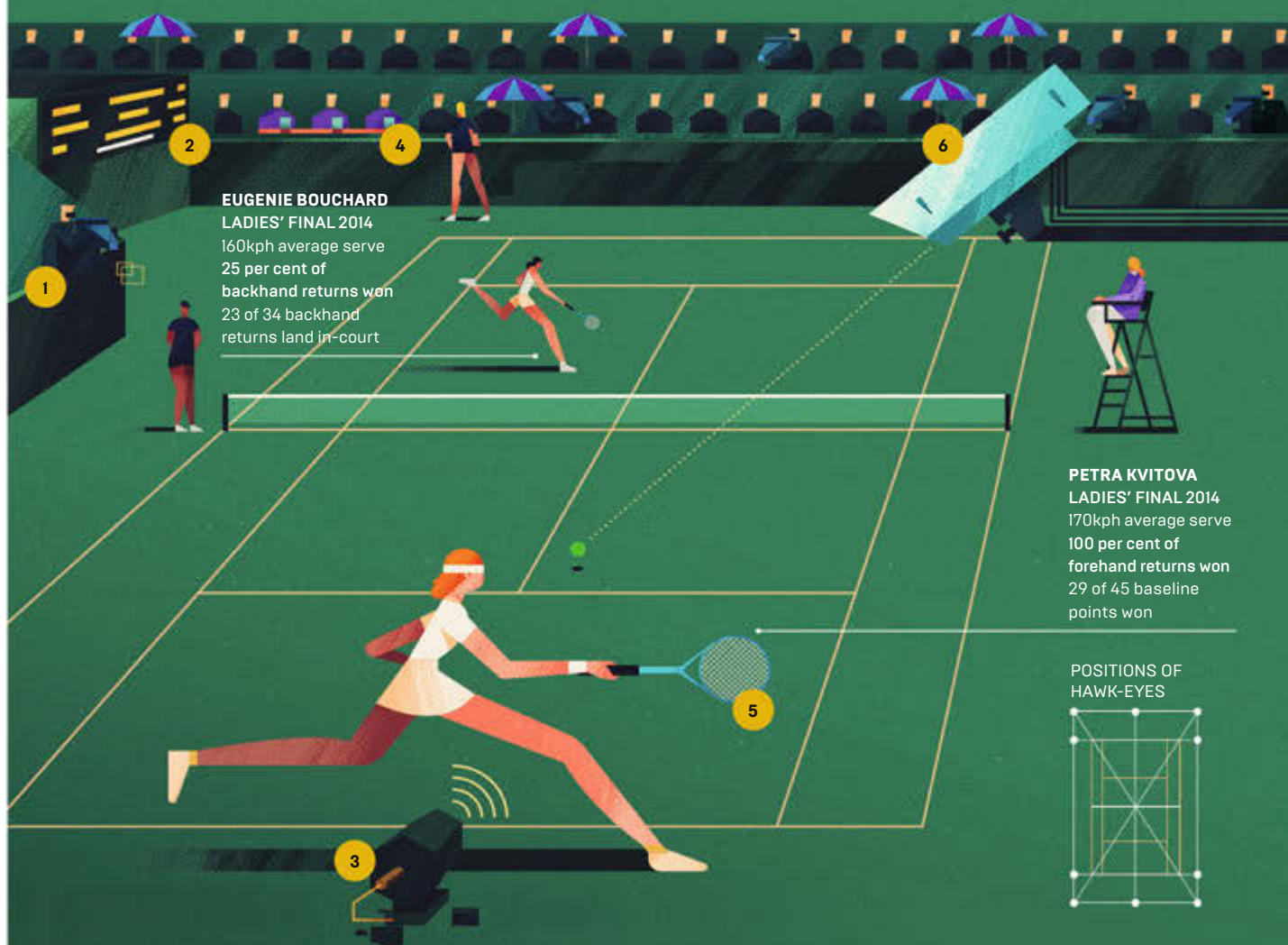
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Advantage: Wimbledon

THE HOME OF TENNIS IS SERVING UP THE FUTURE, FROM PLAYER TRACKING TO SMART RACKETS

When the players walk out on to Centre Court at Wimbledon on June 29, it's not just fans that will be watching – and there were 378 million of them in 2014. From the opening serve, every move at the world's oldest tennis tournament will be tracked – amounting to millions of data points across some 900,000 individual match-points played.

“What we're trying to find is the insights behind the data: not just how the point was won or lost, but what happened in between,” says Sam Seddon, an IBM client executive for Wimbledon, who is tasked with crunching the data. “Given the gladiatorial nature of tennis, any advantage is potentially massive for the players.” WIRED explains the tech behind the tournament. **OF-W** wimbledon.com



EUGENIE BOUCHARD
LADIES' FINAL 2014
160kph average serve
25 per cent of
backhand returns won
23 of 34 backhand
returns land in-court

PETRA KVITOVA
LADIES' FINAL 2014
170kph average serve
100 per cent of
forehand returns won
29 of 45 baseline
points won

POSITIONS OF
HAWK-EYES

1. CAMERAS
Eighteen BBC cameras – including high-speed and 4K – feed five on-site broadcasting trucks and the Wimbledon website, which is updated 140,000 times per day. The future: 360° capture with data overlays for VR.

2. WIMBLEDON INFORMATION SYSTEM
The IBM and Hawk-Eye line-calling data goes to broadcasters, social media and 200 screens around the courts. Players get a USB stick with video and game statistics within 30 minutes of finishing a match.

3. RADAR GUNS
Doppler radar guns at each end of the centre line capture serve speed. The information is fed to the scoreboard in real time.

4. SLAMTRACKER
Three trained analysts – all Lawn Tennis Association (LTA) ranked players – capture match data in real time using a custom input system. They judge subjective data that current computers can't, such as forced vs unforced errors

during play. By combining this with qualitative data – such as ball speed and player movement – the software can identify decisive plays in a game.

5. SMART RACKETS
Allowed since new LTA regulations passed in 2014. Babolat's Play racket – as used by Rafael Nadal – records stroke type, power, angle of attack and spin, feeding data to a smartphone app.

6. HAWK-EYE
Ten 60FPS Sony cameras track the ball. A predictive algorithm can then project the exact location of a bounce to within 5mm. Installed on six courts in 2015, Hawk-Eye also tracks player metrics such as distance covered and speed.

S

quarepusher uses his songs to paint pictures. The Essex-born musician, aka Tom Jenkinson, was bored with the pointless pyrotechnics that accompany many electronica gigs these days, so he directly shapes his live visuals by his music and the environment. "I've been to any number of concerts where it seems the musician feels an obligation to supply visual activity," he says. "Ninety-nine times out of 100 it feels like a distraction, like music playing when the TV's on."

At the heart of each of Jenkinson's gigs is an audiovisual display. The base of each visualisation is made up of control data from a sequencer. It's then augmented by code that instructs the visuals to change based on certain musical elements. "At

the start of the piece, it might be the low-frequency elements that are driving particular parameters, like brightness, so there will be flashes of white," explains Jenkinson, 40. "There might be a point during the piece where those flashes are then driven by high-frequency elements instead, or peaks of volume."

His show for current album *Damogén Furies*, touring until October, brings in an extra component: local data. "Traditionally, video is made up of a red, a green and a blue component," he says. "So we take the average level of humidity, average temperature and average wind speed, for example, and use those to control each colour component." This means each city's show will be influenced by its surroundings, as well as each track. Jenkinson admits, however, there is an ulterior motive to these images. "We live in a culture that

is visually dominant," he says. "I want to hijack that and bring people back to sound."

Sophia Epstein *Squarepusher is appearing at Sonar 2015 on June 19 squarepusher.net*

Lighting driven by data

SQUAREPUSHER'S NEW LIVE SHOW IS GENERATED BY THE CITY



Digital extra!

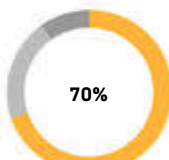
Download the WIRED app to watch exclusive Squarepusher footage



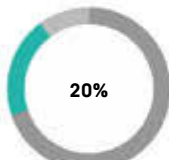
CHARTED

True Detective as a flat circle

Nic Pizzolatto's TV drama returns to Sky Atlantic this summer. But what can we expect this time around? WIRED makes a prediction.



70%
Cryptic, philosophical monologues



20%
Long, uncut tracking shots



10%
Colin Farrell's moustache



SWIPE FATIGUE? LET TINDERBOX CHOOSE FOR YOU

Most bots on Tinder are gold-digging scams – but Justin Long's one just wants to find him a date. "The best and worst feature of *Tinder* is swiping," says the Vancouver-based developer, 26. "My friends and I found it was consuming all our time." (Tinder estimates an average user spends 90 minutes per day browsing prospective dates on the app.) His solution: to create an AI assistant that knows his type, and then let it do the swiping for him.

The bot, called *Tinderbox*, uses a visual algorithm called *Eigenfaces* to analyse the facial features of prospective dates and swipe left or right based on Long's preferences. "If I made 60 choices, it would learn enough to make an educated decision," says Long. The bot then starts up a conversation using a tree of pre-set responses, and uses sentiment analysis to judge if the other person is interested before

notifying Long to take over. "In three weeks it created more than 150 matches, and I went on around ten dates," he says. But doesn't Long worry his creation might seem a little creepy, given the reaction to OkCupid hacker Chris McKinlay (WIRED 03.14)? "One of the first things I would bring up is: by the way, you're talking to a bot," says Long. "That's why girls didn't find it creepy: I told them straight up."

His efforts have garnered interest from *Tinder* and Long

is now looking into licensing the bot to computer-vision researchers. "I think *Tinder* can really benefit from it," he says. "There's so much data, they're going to have to do some visual learning."

As for Long himself, he no longer needs it. "I actually started seeing someone because of it," he says. "So far it's going great."

OF-W github.com/crockpotveggies/tinderbox



Uncontacted tribal peoples are the most vulnerable societies on the planet.



We know very little about them. But we do know there are more than a hundred around the world.

And we know whole populations are being wiped out by violence from outsiders who steal their land and resources, and by diseases like flu and measles to which they have no resistance. All uncontacted tribal peoples face catastrophe unless their land is protected. We're doing everything we can to secure it for them, and to give them the chance to determine their own futures. But we depend on you. **Please, donate now.** Help us prevent the annihilation of another tribe.

Survival International is the global movement for tribal peoples' rights. We depend on you. We need your money, energy and enthusiasm to help us fight one of the most urgent and horrific humanitarian crises of our time.

Visit www.survivalinternational.org for more information or to make a donation.

Survival



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S

o you're a Hollywood film executive who wants to reboot a beloved 80s movie franchise: who you gonna call? Paul Feig. The writer-director has built a reputation for smashing gender stereotypes with box office hits such as 2011's *Bridesmaids* and 2013's *The Heat*. No wonder Sony picked him to helm next year's all-female *Ghostbusters* reboot. "I love working with funny women," says Los Angeles-based Feig, 52. Ahead of his new film, the secret-service comedy *Spy*, Feig talked to WIRED about CIA gadgets, his Yahoo! series and why he ain't afraid of no franchise ghosts. **OF-W**

WIRED: *Spy* isn't so much a parody as a funny take on the genre. Do you think it is making a comeback?

Paul Feig: I'd always wanted to make a spy movie. I'll tell you honestly why I think it's coming back: when *Skyfall* did so well, I think a bunch of us right at that moment were like: "OK, now we've got to make our spy movie."

There's a nod to the genre's obsession with gadgets, but most of the CIA technology in the film is believable.

I was trying to be very accurate and got these two people in from the CIA. I'm like, "Can you do this?" And they said: "Er, we can't answer that." So I had to assume this is technology they would have. I got so tired of the Bond movies of the 70s and 80s that got so gadget-heavy they became like cartoons. You also knew exactly what the plot was going to be: this watch saws through rope! OK, so he's going to get tied up with rope...

You've said that you want your films to pass the Bechdel test [where a movie must feature two women who have a conversation about something other than a man]. They also undermine stereotypes—in *Spy*, the male secret agent. Yeah. I did a lot of research on spies, and it's a known fact that women actually make better spies than men. A lot of >

Paul Feig: "It seems outrageous to have a woman as a spy, but back up: this is how it works"



A REAL LADIES' MAN

PAUL FEIG BUSTS STEREOTYPES WITH HIS NEXT COMEDY

spy work is just gaining people's trust, getting in with people, and women are better at that. So it seems so outrageous to have a woman as a spy, but back up: this is actually how it really works.

Your other current project is *Other Space*, a sci-fi TV series for Yahoo!

Other Space has been a passion of mine for almost ten years. I'm a huge sci-fi fan and I've always wanted to do a sci-fi comedy. Other than something like *Galaxy Quest*, the comedy has always been parody – but for people who love sci-fi, we don't really like seeing it made fun of. I wanted to do something that was funny but smart, like *Doctor Who*, *Red Dwarf* – shows like that.

How was working with a tech company, compared to a traditional TV network?

We had zero interference from them. The biggest thing was getting them to give us a little more money, because with sci-fi you have to build everything – even props. My only fear now is that it doesn't get out there. They have a plan, via their Yahoo! infrastructure, but I just want to make sure this reaches beyond all that and finds an audience.

So: *Ghostbusters*. Were you a fan?

I went to the opening night of *Ghostbusters* and was just blown away. You don't often get those – the other time for me was *Raiders of the Lost Ark*.

What was it that you loved about the original *Ghostbusters* that you're trying to recapture in the remake?

It's such a great jump-off for comedy to have people fighting ghosts. They originally wanted to do it as a sequel, but I didn't know how to do that. Harold [Ramis] had died, we weren't going to get Bill Murray and the scripts always hinged on "the world has forgotten about the *Ghostbusters*" – I don't buy that. It wasn't until they pressed me, and I thought: what if I can put a bunch of funny women in these roles and reboot it so it's an origin story? It's about how they get the group together, how the technology grows – that's interesting to me.

And do we honestly need the all-male version and wider *Ghostbusters* "universe" reportedly in the works too?

[Laughing] I have nothing to do with it. I don't own the property, so they're free to do what they want with it. All I know is that I'm in love with mine. *Spy is released on June 5*



In *Superhot*, time only moves when the player does, which creates intricate puzzles



says. By mixing shooting with strategy games, they created one where time – and enemies, and bullets – only moves when the player does. The result: a combination of chess-like tactics with stylised drama.



Despite Iwanicki's initial team missing an artist – the 3D models were built by two high-school students who offered to help – the game was a hit. Fan hype and a successful \$250,000 (£170,000) Kickstarter followed, with legendary *Gears of War* designer Cliff Bleszinski promising to contribute a level.

After two years of polishing, the finished version takes the innovative gameplay in new directions. "The first version was a game about shooting," says Iwanicki. "Now, it's more about fighting in your own style." Daniel Nye Griffiths *Superhot* for PC, Mac, Linux and Xbox One, is out this month superhotgame.com



CALL OF DUTY, MEET CHESS

PIOTR IWANICKI'S TIME-STOPPING FIRST-PERSON SHOOTER REBOOTS THE GENRE

"Games like *Call of Duty* are gigantic," says Piotr Iwanicki, director of first-person shooter *Superhot*. "To compete, you need a guerrilla strategy."

Iwanicki, 30, conceived the title at 2013's online 7DFPS (seven-day first-person shooter) game jam. With one week to build a working game, his small team brainstormed ideas. "What works best is smashing ideas together," he

James Anderson

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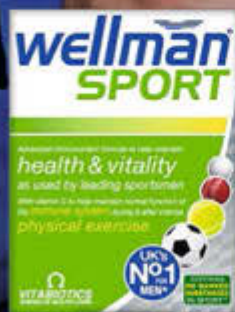
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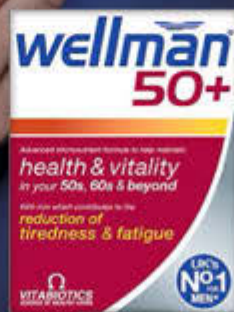
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Mindful music

ARTIST AISTE
NOREIKAITE
WANTS US TO
LISTEN TO
OUR BRAINS



This is no ordinary hard hat. Created by artist Aiste Noreikaite (*pictured*), the Experience Helmet aims to read the wearer's thoughts to create an unexpected soundscape. "I originally just wanted to make a helmet with a psychedelic soundtrack," says the London-based Lithuanian. "But then I found out about electroencephalography [EEG] devices. It creates an element of surprise."

Inspired by Buddhist thought and meditation practices, the Experience Helmet is designed to enhance self-awareness. An EEG sensor embedded within the helmet measures the wearer's brainwaves; a built-in processor then interprets the data and uses it to generate a surreal soundtrack.

"My main goal was to translate the brainwaves as accurately as possible," says Noreikaite, 23. "I did this by using electronic sounds because it relates to the electrical movements between the neurons." The helmet can also affect your thoughts using binaural beats. "If you play one tone, for example 330Hz, to one ear, and 340Hz to the other, the brain produces a low-frequency

pulsation, which is the difference between those tones," Noreikaite explains. "It might be 2Hz to induce delta brainwaves [the waves that are associated with REM sleep] or 20Hz for beta waves, which are most active when we think logically."

Noreikaite now aims to delve deeper and create a more complex and nuanced experience for the wearer. "I want to dig more into brains and explore how they work," she says. "I want to try and translate human emotions."

Emiko Jozuka aistenoreikaite.com



Digital extra!

Download the WIRED app to listen to Aiste Noreikaite's brainwaves



SPOTIFY'S 20% NEED LOVE TOO

An estimated four million songs available on Spotify – 20 per cent of its library – have never been played, according to San Francisco-based designer Lane Jordan. His solution is Forgetify, a web tool that unites every overlooked track in one place. “We’ve come across almost every genre you can think of, and a few you couldn’t even imagine,” says Jordan. “From classical to jazz, Balkan beat, German polka dancing and more. Most of the artists are forgotten for a reason, but every now and then someone comes across a gem.” Here are Jordan’s as-yet-unstreamed highlights, selected for WIRED. **OF-W** forgetify.com



1
“Little Boy Sad”
by Ray Burgess



2
“Room Full Of Losers”
by Jimmy Arthur Ordge



3
“Payday”
by Dave Moore



4
“Just For Tonight”
by Frannie Golde



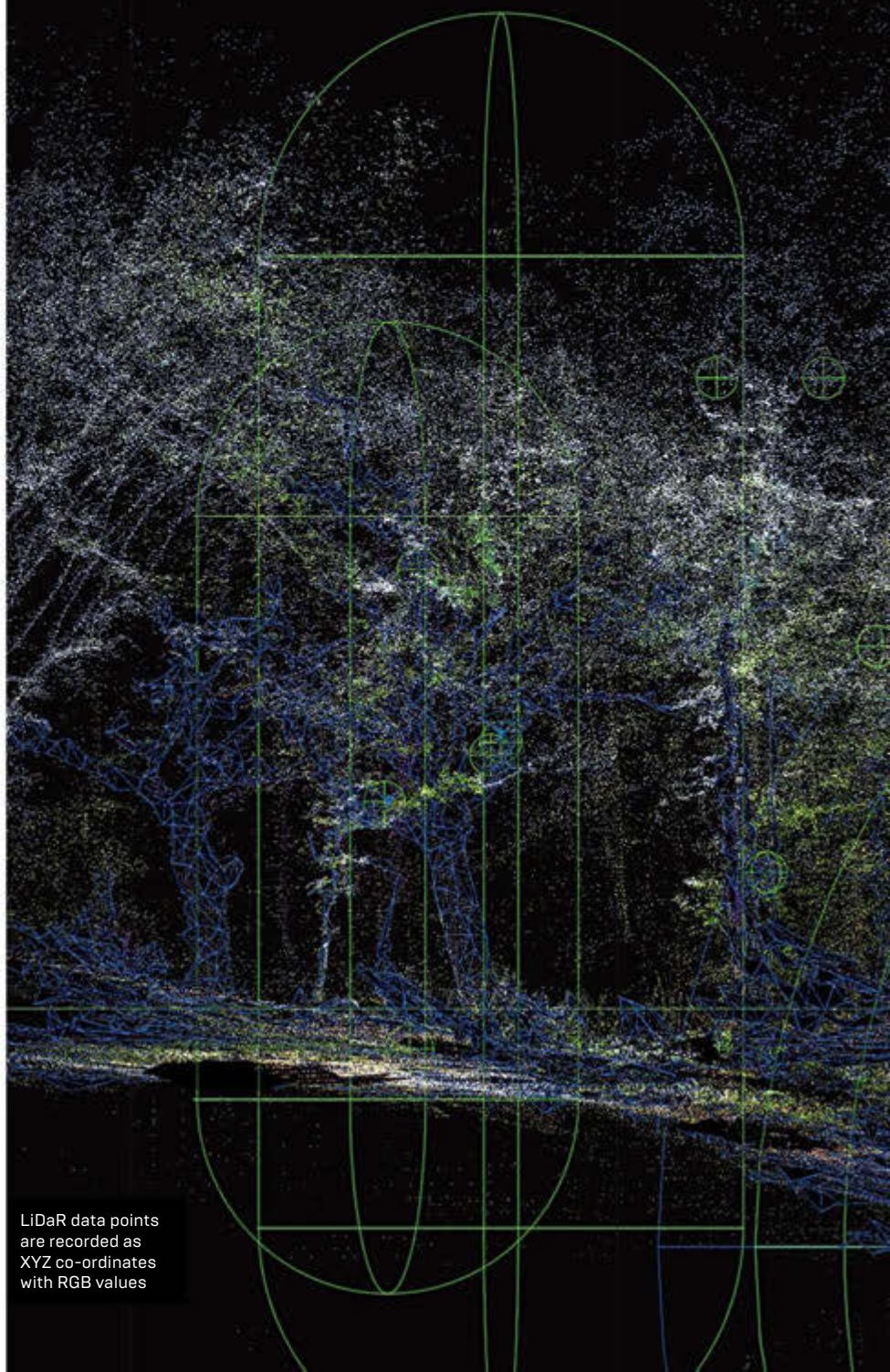
5
“Prime Step”
by The Kay LC



6
“Tinh Gian Doi”
by Tam Anh

Scanning the great outdoors

DATUM EXPLORER TURNS UK WOODLAND INTO A
DIGITAL INSTALLATION – WITH ADDED BEARS



LiDaR data points
are recorded as
XYZ co-ordinates
with RGB values

U

niversal Assembly Unit is transforming Britain's rural corners into an interactive digital landscape. The multi-disciplinary artists – William Gowland, Samantha Lee, Oliviu Lugoian-Ghenciu and Zhan Wang – explore spatial design by creating multiplatform virtual artworks. “A lot of our projects look for ways to connect familiar physical experiences with new, virtual ones,” says cofounder Samantha Lee, 26. “We’re

interested in technologies that redefine the ways we can experience space.”

To create the piece *Datum Explorer* (pictured), the team took a 3D LiDaR laser scanner and binaural recording equipment to map woodlands in Great Park Farm, East Sussex. They then combined the data set with a game engine to create a virtual woodland – with the addition of once-native animals, such as wild bears (inset). “It’s a response to the increase in simulated environments and immersive virtual realities such as Oculus Rift and augmented reality,” explains Lee. “We wanted to show this in a different context, take it away from the gaming industry and explore new ways of defining nature and our relationship with technology.” The result is a ghostly-looking habitat where point clouds, created by the scanning process,

become the defining aesthetic. The raw visual data becomes a digital material imbued with its own poetry. “When you walk through the virtual forest the points start to disappear,” says Lee.

The piece, showing at the Sónar+D festival in Barcelona, June 18-20, can be explored as an immersive installation projected on to multiple walls, and as a PC and smartphone app. “As an experience it adds another level to what one would feel in the physical world,” explains Lee. “It’s not about mimicking nature, but creating new ones.”

Kevin Holmes universalassemblyunit.com



Field recordings and sounds for each animal are placed throughout the virtual site

A selection of wire-frame animals stalks the terrain, triggered by the user's movements



Digital extra!
Download the WIRED app to see more of *Datum Explorer*

► EDIFICE AWARDS

Unimpressed by your everyday surroundings? Architizer's A+ Awards 2015 book recognises the most impressive spaces of the year, including Abiro's Planica ski jump in Slovenia (pictured). architizer.com



▲ HE REALLY IS BACK

Reboot-cum-sequel *Terminator Genisys* confuses the series even further – time travel! cyborgs! – but you'll want to see it for Arnie, through the magic of special effects, fighting his own 80s incarnation. Out on July 3



Playlist

082 / **PLAY** / CULTURAL PICKS OF THE MONTH / 07.15



◀ THE EX-XX STAR

British producer Jamie xx – he of The xx – releases his first solo album, a catholic mix that includes collaborations with Four Tet and Young Thug, and spoken-word samples from TV show *Top Boy*. Out now. jamiexx.com

▼ IMPOSSIBLE FURNITURE

This chair could not have existed without 3D-printing. The foam-rubber structure – built by Alvin Huang with a Stratasys machine – shifts from soft in some areas to hard in others. synthesis-dna.com

▲ FINALLY, ROBOT BUTLERS

Adapted from the Swedish series *Real Humans*, Channel 4's new drama is set in a world full of robot servants or "Synths". The actors consulted robotics experts to nail down their uncanny behaviour. *Humans* starts on Channel 4 in June.

▼ PAPER GAMING

The stunning "world of paper" title *Tearaway Unfolded* comes to PS4. Using a DualShock 4 touchpad, players control the action by making gusts of wind with a finger-flick. Out soon. tearaway.media-molecule.com

▼ THIS IS A PHOTO

Julian Opie takes photographs and then digitally alters them, picking and choosing individual segments until he is left with thick-lined, modern prints. See them at the Alan Cristea Gallery in London from June 5 to July 18. alancristea.com



BUPA HAS VOWED TO TACKLE ONE OF THE MOST WIDESPREAD AND DEADLY ISSUES IN GLOBAL HEALTHCARE

BUPA / WIRED HEALTH

**THOUGHTS
AND OPINIONS
FROM THE BUPA
HYPERTENSION
CHALLENGE**

MACHINE LEARNING

"The smartphone delivers the service, and the back end uses machine learning or artificial intelligence. Having these two together allows you to create that deeply personal two-way communication." *Garry Fingland, CIO, Bupa on how some jobs are better suited to machines*

NO EASY ANSWERS

"The workshop made me realise that small, concrete help and ideas can come together to make a big difference, but only if well targeted to the individual and well co-ordinated over the longer term. There are no magic bullets." *Ben Fehnert, cofounder, SP+EE*

COMMUNITY POWER

"We need to treat patients as people, and work upon their emotions and aspirations. If we replicate this within the healthcare industry, there would be a dramatic change in the way that problems such as hypertension are treated." *Jorge Armanet, CEO, HealthUnlocked.*

The Bupa Hypertension Challenge



Martin Kohn, chief medical scientist, Sentrian



Holly Gray, prevention and wellbeing advisor, Bupa



Alma Adler, science officer, World Heart Federation



Shahid Azim, cofounder, Quanttus

The second annual WIRED Health event, which took place on April 24, was about tackling the biggest questions and issues facing the future of healthcare. So, it was the perfect venue for Bupa and its partners – the World Health Organisation, the International Telecommunication Union and the World Heart Federation – to address one of the greatest challenges in healthcare: hypertension.

Around one third of the adult population of Earth lives with hypertension, which contributes to 45 per cent of deaths from heart disease and just over half of all stroke-related deaths. However, only half of this huge group even knows that they are affected, and fewer than 20 per cent are receiving treatment to combat its effects.

Changing attitudes and approaches to hypertension could be a life-saver. These require not just new technologies, but new thinking. That's why Bupa gathered a group of practitioners, startups and representatives of software and service giants the day before WIRED Health. Their assignment: a workshop to plan a global attack on hypertension.

For a global problem, a one-size solution will never fit all. Frog, the design agency leading the workshop, created a series of personalities to reflect the huge diversity of people at risk of hypertension, or living with high blood pressure.

Bjorn, a 32-year-old accountant in Sweden with a healthy lifestyle, needs a different kind of intervention, and has access to differing resources than Bertha, a 62-year-old South African housekeeper with diabetes, or Kaleb, an IT worker in Mumbai with a stressful job and a taste for fast food.

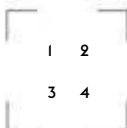
Yet common themes emerged. Community is vital, whether Bertha's church or Kaleb's online colleagues. As smartphones spread to the developing world, mobile education becomes a priority. And those mobile devices can also provide shortcuts to medical attention and collate data that can identify risks before they become realities.

WIRED Health is about the ideas that change how we manage illness. The Hypertension Challenge has the potential to have a transformative impact on global health. *For more, visit bupa.com/mhealth*



Events, new products and promotions to live the WIRED life

Compiled by
Cleo McGee



1/Valentino Uomo Edition Noire

Reimagining the original Valentino Uomo fragrance by perfumer Olivier Polge, Uomo Noire combines zesty bergamot with a hint of spice, alongside musky white leather, cedar and smoky wood. The spiked black bottle evokes the feeling of excitement and moody sophistication. **£64.50 (100ml)**
valentino.com

2/Smeg SMF01 stand mixer kitchen appliance

Add retro style to your kitchen with the beautifully crafted Smeg mixer. With its sleek and curvaceous figure, the mixer combines Smeg's iconic 50s-inspired design with excellent build quality. The result is a futuristic yet practical piece of essential home kitchen technology. **£379.99**
smeguk.com

3/Tiffany his and hers timepieces

For the couple that has everything, Tiffany provides a new proposition. The CT60 34mm women's watch is a stainless-steel design set with round brilliant diamonds. And for him, there's the CT60 Chronograph 42mm timepiece in stainless steel with black alligator strap. **£7,125 and £5,475**
tiffany.co.uk

4/Marshall Monitor headphones

Turn it up to eleven with Marshall's vintage over-ear cans. The Monitor series ship with felt treble-filtering inserts for superior sound delivery, and the detachable headphone cord features a built-in mic and remote, which can be inserted into either ear side. **£170**
marshallheadphones.com

WIRED INSIDER'S PICK OF UPCOMING EVENTS

WIRED MONEY

The British Museum will be the venue for the third WIRED Money – a showcase for disruptive people and businesses shaking up the financial sector. Topics include digital currencies, crowdfunding, trust and security, plus the democratisation of investment. **July 8, 2015**
wired.co.uk/money15

WIRED 2015

Back for a fifth year, the WIRED annual two-day event welcomes innovators and entrepreneurs in design, music, tech, science and more to speak and network with 800+ delegates. More than 50 speakers will make this the biggest WIRED event yet. **October 15-16, 2015**
wired.co.uk/15

WIRED NEXT GENERATION

Now in year three, Next Generation is formulated for young people, to inspire the innovators of tomorrow. Providing workshops, music performances and talks, previous speakers include musicians Rizzle Kicks and actor Andy Serkis. **October 17, 2015**
wired.co.uk/nextgen

WIRED RETAIL

For a second year, WIRED Retail will reveal how technology is turbo-charging this sector. Speakers in 2014 included Farfetch, Etsy, Shutl, Lyst and Instagram, while insights covered the future of delivery, blogs as commerce platforms, and the Airbnb for retail leasing. Unmissable. **November 19, 2015**
wired.co.uk/retail15
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ILLUSTRATION: JANNE IVONEN

How to...

Dive like a seal

In almost ten years as a competitive freediver, Hanli Prinsloo set 11 South African records. She has held her breath for five minutes 39 seconds in the pool and dived 63 metres under the Red Sea on a single gulp, so she knows about aquatic capabilities. "The human body is adapted to freediving in ways we once believed belonged only to the deep-diving aquatic mammals," says Prinsloo, 36, referring to the dive reflex. It starts when your face touches cold water. "Your heart slows to conserve oxygen," says Prinsloo. As you hold your breath, vasoconstriction sets in, >



sending oxygenated blood from muscles to organs. The spleen releases oxygen-rich red blood cells and finally, as the pressure increases during dives, vessels in the lungs swell to prevent collapse. Since last competing in 2012, Prinsloo has travelled the world to promote ocean conservation through her I Am Water foundation. Here's how to channel your inner pinniped. **Daniel Cossins**



4. TAKE A BIG GULP

You need to be able to take the deepest breath possible. Breathe out all the air in your lungs. Inhale slowly, first into the stomach, then the lungs, feeling your chest expand. "Finally, fill the last little bit up behind the collar bone," says Prinsloo. "Now the key is to relax with feeling overfull." Breathe in to full capacity and hold for as long as is comfortable. Exhale when you feel the need.

1. BECOME BREATH-AWARE



"First, you must become a conscious breather," says Prinsloo. Sit still or lie on your back, and feel the air move in and out of you and the muscles controlling it. Feel the diaphragm pulling down and drawing air into your lungs while muscles between the ribs stretch to expand the volume. Think of the oxygen circulating around your body and the expulsion of carbon dioxide.



5. MAKE IT LONGER

Rest and then go again, but this time hold on for a few seconds past the trigger until you start to feel a pulsing sensation in your abdomen. That's your diaphragm contracting. Next time, try to go past that point by counting slowly to avoid focusing on the discomfort. "You should notice a significant increase in the length of time you can hold your breath," says Prinsloo.

2. STRETCH YOURSELF



"Your lungs could expand more than the muscles seem to allow, so we stretch," says Prinsloo. Kneel on the floor with bum on heels and back straight. Take a full breath and straighten your arms over your head. Hold for 20 seconds or as long as is comfortable, then exhale. Take a big breath and lean gently to one side with your arm reaching over to open the intercostal muscles. Hold for 20 seconds on each side, or as long as you can.



6. DIVE IN

"Make sure that when you get into the water, each dive feels like the first easy breath hold. Never push yourself in the water," says Prinsloo, "and never enter the water alone." With your buddy watching closely, take a deep breath, counting your inhalation for four seconds, then breathe out for eight. "This will slow down the heart rate, conserving oxygen and putting you into a trance-like state of relaxation."

3. MASTER BELLY BREATHING



"You need to really think about your breathing," says Prinsloo. Lie flat on your back and breathe into your stomach. Take deep, slow breaths and feel your stomach rise and fall with the movement of each breath. "Try to direct air into the stomach so you don't feel any expansion in the chest," says Prinsloo. "Count your inhalation to six seconds and exhale for ten. This type of belly breathing will help you take bigger breaths."



7. AND RELAX

When you're ready, take that one last long breath and dive. Move smoothly and avoid jerky actions to save energy, and remember to equalise the pressure in your ears as you go deeper. When you gain more experience, you can also use a weight belt. "Aim for just the right amount of weight so that you can still float comfortably at the surface but you don't have to waste oxygen trying to stay down when you dive," says Prinsloo.

ILLUSTRATION: JANNE IVONEN; VALERO DOVAL

086 / HOW TO / FREE ENTERTAINMENT / COOL RECEPTACLE

How to...

WATCH A FILM FOR FREE

With built-in DVD drives deemed outdated and piracy fines skyrocketing, watching a film on your computer is getting more and more difficult. But Dan Colman can help: the director of Stanford's continuing studies program has built an online database called Open Culture, a compilation of links to public-domain resources deep in the internet. "I started the site over eight years ago to help people use the web for enriching purposes," says Colman. The film section is one of many lists available online, enabling even those who don't have Netflix to binge-watch. Sophia Epstein

OPEN CULTURE

Catering to all cultural persuasions, Open Culture holds material from audiobooks to language lessons. It's divided by genre, and even has Colman's recommendation: *The Cabinet of Dr Caligari*. openculture.com

YOUTUBE

There's a wide selection of films you can enjoy for free in YouTube's Movie section. Fans of low-budget horror, underrated comedies or golden oldies will not be disappointed.

FILM ANNEX

Not the most modern-looking layout, the Annex has an eclectic mix – Laurel and Hardy shorts, Superman and Popeye cartoons and Charlie Chaplin films. Plus, the 1931 classic, *Dr Jekyll and Mr Hyde*. filmannex.com

Forget ice cubes – keep your drinks chilled from the outside in by using simple household equipment to make solid-ice shot glasses. Polymath and YouTuber Cordell von Malegowski explains how. Rachel Walker



How to...

Make a shot glass out of ice

1

MAKE A MOULD

Stick one end of a duct-tape strip to the inside of a shot glass, and the other on the outside of a lowball glass. Repeat this at four points, making sure that the shot glass is firmly suspended in the middle. "Paper cups are too flimsy, and plastic cups don't have enough weight to be accurately centred," explains von Malegowski. "A glass tumbler and shot glass seems to solve the problem."

2

ADD WATER

Fill the void between the glasses with tap water, but be careful not to overfill it. "Regular water expands as it freezes," von Malegowski explains. By leaving the top open, the water will push upwards. If the glass had a lid, it might crack as the water expanded. "As a precaution, a thick-walled glass should be used to ensure nothing goes wrong," suggests von Malegowski.

3

GET CREATIVE

Von Malegowski uses drops of edible food colouring to introduce a flash of colour to some of his shot glasses. "I did try using fruit juice," he says. "It melted too quickly and it made people's hands sticky." Similarly, alcohol freezes at a lower temperature than water, but a low-proof cocktail mix can be used to make a flavoured glass.

4

FREEZE

Transfer the filled glass moulds to the freezer for several hours, to allow them to set solid. "I put them on wire racks," says von Malegowski. "A piece of wax paper also prevents the glasses from sticking to the base of a drawer or tray."

5

ENJOY

To free the ice glasses from the mould, remove the duct tape. Lift out the shot glass, then run the Old Fashioned glass under the tap. This starts to melt the outer layer just enough to loosen it from the glass. Store in the freezer until ready to use. "They're great for outdoor winter parties," explains von Malegowski. "I make a batch before New Year's, then they come out of the freezer for some shots, then go back in."

OVGUIDE

This extensive database is full of options. If you don't mind trawling through some gory horror and hours of wrestling, there are some gems, from star-studded flicks to small film-festival award-winners. ovguide.com

UBUWEB

The jackpot for fans of the avant-garde, this offers more than 2,500 features, as well as shorts by famous names such as Andy Warhol and Samuel Beckett. ubu.com

INTERNET ARCHIVE

With 1.9 million video items to choose from, the Archive has films ranging from the silent to the subtitled. The collection is dominated by the black and white; from Humphrey Bogart and Cary Grant romances to horror films. archive.org



Build a VR headset

How to...

1. GATHER THE COMPONENTS

To make your own custom VR headset, you'll need a sheet of 5mm-thick black foam-board, 40cm x 40cm or larger; a hot-glue gun and glue; a pair of metal-framed reading glasses; two aspheric magnifying lenses around 3cm in diameter, with roughly a 5x magnification (possible sources include binoculars, toys, or a VR lens kit); and around 120cm of 3cm-wide elastic. You'll also need a smartphone; a gyroscopic mouse; and headphones with a sturdy support in the middle. You will then need to choose your software.

2. CUT OUT THE FRAME

First find and record the focal length of your lenses by measuring at what distance an object comes into focus. Cut two pieces of foam board for the top and bottom in a rectangle as wide as your glasses hinge-to-hinge. Cut them as long as the new lens focal length, multiplied by 1.5 for the top, and this length plus 1cm for the bottom. Cut two side pieces the same length as the top piece and as wide as your phone's height in landscape mode. Finally, cut out a piece to cover the front as wide as your glasses in one direction and as high as your phone's landscape height in the other. Cut out a rectangular section in the middle of the front piece 5-10mm smaller than your phone in both dimensions.

3. GLUE YOUR FRAME

Line up the top and bottom pieces of foam board, then cut a semicircle roughly the size of your face into one of the shorter sides on each. Into this semicircle make a cut-out for your nose on the longer bottom section. Glue the top and bottom to the sides with both semicircles aligned, forming an open box. Glue the front section to it, resting on the bottom's protruding edge, forming the body of your headset. Poke holes in the sides at the focal distance from the outside of the viewing window and about 60 per cent of the way from the bottom. Replace the original lenses with your magnifying lenses, gluing if necessary, and feed the earpieces of your glasses through the holes. Cut the earpieces to a few centimetres in length, and hot-glue them to the outside.

4. ATTACH AND TRACK

Attach a piece of elastic to the sides so it fits snugly over the front piece of the headset; this will be used to hold your phone in place. Fasten a second piece of elastic roughly half the diameter of your head on the sides and near the back to strap the headset to your face. To track head movements, attach the gyroscopic mouse using hot glue and foam board as necessary on top of your earphones, pointing in the same direction as your face. Turner tried attaching this to the head-mounted display unit but the extra weight was uncomfortable and tiring.

5. LET VR COMMENCE

First, you'll need a game that supports side-by-side 3D imaging, displaying a slightly different image for each eye on the same screen. For games that don't support this, a piece of software (try TriDef 3D) or a game modification (like *Minecraft* – a 3D mod of *Minecraft*) may help. You need to be able to mirror your computer monitor on a phone using a program such as Kainy for Android or Splashtop for iOS. Finally, a program to adjust your head-tracking mouse separately from your main mouse can set up your hand for larger movements, while the gyroscopic mouse is used to look around. Once this is working, insert your phone, put on your headset and escape into your own virtual world.

V

irtual reality has been "the future" for at least 20 years (*see feature on p120*). Although it's not yet common to see someone using this type of display, technology has advanced enough that you can build one using off-the-shelf components. College student Austin Turner

([youtube.com/user/ohaple](https://www.youtube.com/user/ohaple)), made his own working headset using a smartphone. It took several experiments, including one made out of Tupperware, as well as a model using a webcam for tracking. Here's how to make your VR headset real. Jeremy Cook

How to...

Touch type at speed

Many of us can bash out a text message without thinking, but typing using all of our fingers and a keyboard is more of a challenge. Touch typing at speed is an invaluable skill – the average person can type at 40 words per minute, but with a little training this can be boosted. And it's not as difficult as you think.

"A lot of people could easily reach 80 words per minute," says Christian Strang, developer of online typing test site 10fastfingers.com. Here are his tips. SE

1. Master the middle row

Your resting position should be on the keyboard's centre line – left pinkie on the A key, right pinkie on the semicolon, with only G and H uncovered. Reach up and down from there. Your thumbs stay on the space bar, no exceptions.

2. No peeking

The best way to prevent sneaking glances at the keys under your fingers is by taking away the option. A napkin or tea towel works perfectly, and will motivate you to quickly learn where the backspace key is.

3. Keep going

There are lots of resources online – from free games and tests such as *Desert Typing Racer* and *TypingClub*, to paid courses like *Type Fu*. Choose one with increasing levels of difficulty, including numbers and punctuation.



How to...

MAKE YOUR OWN WINE AT HOME

Manufacturing wine brings to mind artisans with years of experience, crafting an expensive and refined vintage beside a picturesque vineyard. If you don't own such a place, and are in more of a hurry, you can still make your own wine at home. Trevor van Hemert uses a variety of methods, but this process for producing wine directly from grapes is a simple starting point for budding vintners. JC

WHAT YOU'LL NEED

To produce the juice, obtain 40kg of not-too-ripe grapes from a farmer's market, a grape press and a 30-litre bucket with a seal. You'll also need 3–4kg of sugar and a wine or Champagne yeast packet. For fermentation, get a 25-litre plastic or glass water bottle, a rubber stopper with a 6mm hole in the middle, an airlock, a stirrer able to reach into the glass bottle, a funnel, a turkey baster and a siphon (an autosiphon device from a homebrew shop is best). You'll also need a solution with which to sanitise your implements. Coffee filters and a hydrometer will help you to perfect your wine, but they're not essential.



SANITISE EVERYTHING

Unwanted bacteria would love to live in the vat of sugar-water that you will be making, so it's best to keep them out from the start. Before embarking on (and during) your wine-making journey, clean all implements that will touch your juice. Van Hemert uses a solution called PBW to wash his implements, and Star San to eliminate organisms still residing on his equipment. Home brewers are quite adamant about cleanliness, citing this as the most critical aspect for successful fermentation.



JUICE YOUR GRAPES

Rinse your grapes, then insert them into the wine press – manual models using a crank and a huge screw in the middle are ideal. Crush the grapes so the juice runs into the 30-litre bucket. Let it sit for a few days to allow sediment to collect on the bottom. Raise the bucket above the 25-litre fermentation vessel, known as a carboy, and siphon the juice into it, holding back a litre or so. Keep the hose out of the sediment on the bottom of the bucket and use a coffee filter on the siphon hose to eliminate even more detritus.



MIX IN SUGAR AND YEAST

Insert a funnel in your carboy and add 3kg of sugar. Stir the sugar and juice for around two minutes. Use the funnel to pour in yeast. Siphon the remaining juice into the jug to wash the yeast down, leaving about 10cm of space between the juice and the neck of the bottle. This will allow foam to build up during fermentation. Van Hemert prefers his wine to be in the 15 per cent alcohol-by-volume range. Optionally, to ensure this level of alcohol, sample the sugar content with your turkey baster and test its "gravity" with a hydrometer. If it is too low, add sugar in small increments, then stir and re-test.



AIRLOCK AND WAIT

Using the stopper, attach your airlock. This will let gasses escape during fermentation, while keeping sediment out of your fermenting wine. Place this bottle somewhere cool – around 20°C – where it won't be disturbed, then wait four weeks. Check, but don't remove, the airlock a few times in the first few days to make sure it's functioning correctly. After four weeks, take a sample out with your turkey baster and taste. If it tastes good, move on to bottling. If not, let it age for another week or so and repeat.



BOTTLE YOUR WINE

Remove the airlock and lower your siphon into the liquid, making sure it doesn't rest on the yeast that has collected on the bottom of the container. Place the large fermentation container above the bottles to be filled. Suck on the siphon tubing to start the process, then regulate the flow of the liquid into the bottles with your finger and thumb. If you want to eliminate much of the yeast before bottling, you can place a coffee filter over the siphon tubing to catch it. Once your bottles are full, put the caps on securely. Congratulations – you've just bottled your first batch of wine. Enjoy responsibly!

NEXT ISSUE
ON SALE JULY 2

WIRED

THE

WIRED
LOVES

#1 DJI
Inspire 1
camera
drone



PRODUCT SPECIAL,
STARRING OUR
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SIMON PEGG →

YOUR ULTIMATE GUIDE TO LIVING
THE WIRED LIFE, FEATURING
JETS, TOYS, ROBOTS, FOOD...



FEATURES

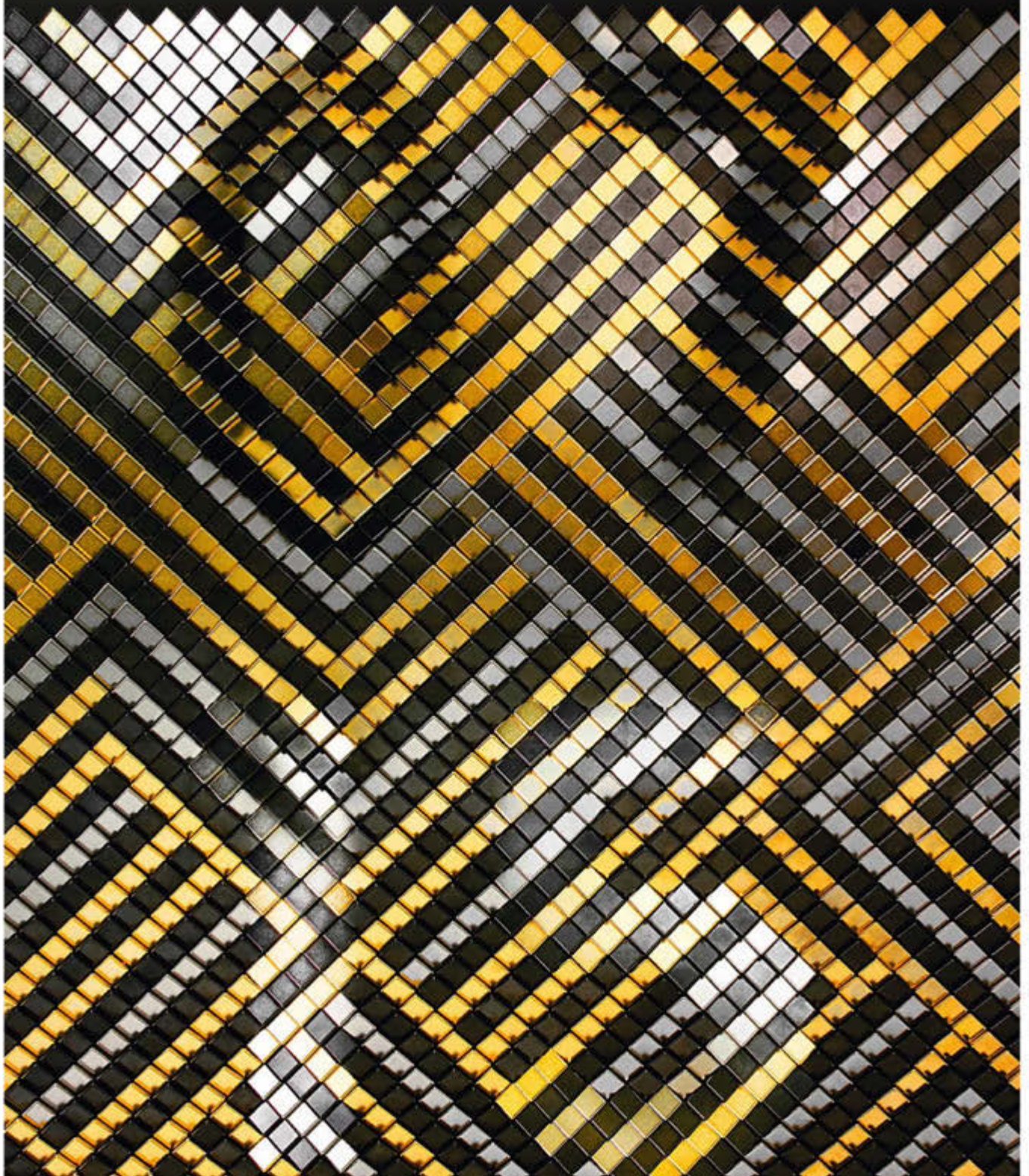


IMAGE: GILES MILLER STUDIO, USING CAST ZINC TILES, POWDER-COATED AND PLATED IN A VARIETY OF METALLIC FINISHES

"Maybe one day there'll be an AI listed among the authors of a *Nature* paper." Demis Hassabis, p92



PHOTOGRAPHY: MACIEK JASIK

INSIDE

GOOGLE'S SUPER-BRAIN

BY

DAVID ROWAN

DEEPMIND'S DEMIS HASSABIS

IS BUILDING THE ULTIMATE AI.

SHOULD WE BE AFRAID?

THE FUTURE OF ARTIFICIAL INTELLIGENCE BEGINS WITH A GAME OF SPACE INVADERS.

From the start, the enemy aliens are making kills – three times they destroy the defending laser cannon within seconds. Half an hour in, and the hesitant player starts to feel the game’s rhythm, learning when to fire back or hide. Finally, after playing ceaselessly for an entire night, the player is not wasting a single bullet, casually shooting the high-score floating mothership in between demolishing each alien. No one in the world can play a better game at this moment.

This player, it should be mentioned, is not human, but an algorithm on a graphics processing unit programmed by a company called DeepMind. Instructed simply to maximise the score and fed only the data stream of 30,000 pixels per frame, the algorithm – known as a deep Q-network – is then given a new challenge: an unfamiliar *Pong*-like game called *Breakout*, in which it needs to hit a ball through a rainbow-coloured brick wall. “After 30 minutes and 100 games, it’s pretty terrible, but it’s learning that it should move the bat towards the ball,” explains DeepMind’s cofounder and chief executive, a 38-year-old artificial-intelligence researcher named Demis Hassabis. “Here it is after an hour, quantitatively better but still not brilliant. But two hours in, it’s more or less mastered the game, even when the ball’s very fast. After four hours, it came up with an optimal strategy – to dig a tunnel round the side of the wall, and send the ball round the back in a super-human accurate way. The designers of the system didn’t know that strategy.”

In February, Hassabis and colleagues including Volodymyr Mnih, Koray Kavukcuoglu and David Silver published a *Nature* paper on the work. They showed that their artificial agent had learned to play 49 Atari 2600 video

games when given only minimal background information. The deep Q-network had mastered everything from a martial-arts game to boxing and 3D car-racing games, often outscoring a professional (human) games tester. “This is just games, but it could be stock-market data,” Hassabis says. “DeepMind has been combining two promising areas of research – a deep neural network and a reinforcement-learning algorithm – in a really fundamental way. We’re interested in algorithms that can use their learning from one domain and apply that knowledge to a new domain.”

DeepMind has not, admittedly, launched any products – nor found a way to turn its machine gameplay into a revenue stream. Still, such details didn’t stop Google buying the London company – backed by investors such as Elon Musk, Peter Thiel and Li Ka-shing – last January in its biggest European acquisition. It paid £400 million.



On DeepMind’s website, the company’s mission is explained simply as to “solve intelligence”. As Hassabis describes it, it comes down to a multi-decade Apollo-style project to crack artificial general intelligence (AGI): rather than teach the machine to understand language, or recognise faces, or respond to voice commands, he wants machine learning and systems neuroscience to teach the network to make decisions – as humans do – in any situation whatsoever. “The dream of AI is to make machines smart,” he explains in the new six-storey King’s Cross building that houses 150 DeepMind staff. “Most AI today is about preprogramming a machine. Our way is to program them with an ability to learn for themselves. That’s much more powerful; that’s the way biological systems learn.”

“We refer to it as an Apollo programme, a Manhattan project, in terms of the quality of the people

involved – getting 100 scientists, here from 40 countries, together to work on something visionary and trying to make as fast progress as possible. We’ve brought together the world’s top computational neuroscientists as well as machine-learning experts with huge engineering resources, to see how far we can push.”

Artificial intelligence tends to get a bad rap in popular culture: as cyborg assassins in *Terminator*, or operating systems, like Samantha in *Her*, that lure us into unwitting love. So why do we need a general form of AI at all? “I think we’re going to need artificial assistance to make the breakthroughs that society wants,” Hassabis says. “Climate, economics, disease – they’re just tremendously complicated interacting systems. It’s just hard for humans to analyse all that data and make sense of it. And we might have to confront the possibility that there’s a limit to what human experts might understand. AI-assisted science will help the discovery process.”

Still, AGI won’t be here any time soon. “We’re trying to build a single set of generic algorithms, like the human brain,” he says. “We’re trying to build things with generality in mind. The *Nature* paper was the first baby steps. You need to process vision; you need long-term memory; you need working memory so you can switch between tasks... Today you can create pretty good bespoke programs to solve specific tasks – playing chess or driving a car. Our system could learn how to play chess, but it’s not going to be better than Deep Blue. You give it all the knowledge it needs – the moves, the openings, the endgames. But where does the intelligence reside in something like Deep Blue? It’s not in the program, it’s in the minds of the programming team. The program is pretty dumb; it doesn’t learn anything.”

Hassabis runs DeepMind according to a “20-year roadmap”. “General AI isn’t the sort of thing you can wake up one morning and say, that would be a cool thing to do a startup on. I’m trying to fuse together a deep understanding of computer science and neuroscience, to understand systems neuroscience – the algorithms the brain uses, the representations it has for knowledge, its architecture. As opposed to the EU Human Brain Project, which is trying to reverse engineer at the cortical-column level. That’s too low-level for us.”

So how will his project affect our lives within 20 years? “Science

for sure will benefit – within drug discovery, protein folding, anything where there's a huge amount of exploration," he says. "Of course we'll have self-driving cars – but that's narrow AI. We'll have things that can start being creative in 20 years. A lot of things that look very complex, when you break them down it becomes clear how the apparatus works. I studied imagination. We did brain scans, found areas of the brain involved, built models. That made me think that most processes can be understood, including creativity." An AI making an entertaining movie? "I'm thinking more on a basic level – putting disparate things together to make a new hypothesis. A novel or film is many decades away, though with music, a more limited domain, there are already passable projects that hint at what's possible."

ARTIFICIAL INTELLIGENCE TIMELINE	
1837	1950
Charles Babbage designs the Analytical Engine – a mechanical computer he never had the funding to build.	Alan Turing publishes a paper introducing the Turing Test, beginning with the question 'Can machines think?'
1910	1954
Alfred Whitehead and Bertrand Russell publish the first volume of the landmark work <i>Principia Mathematica</i> .	George Devol applies for a patent on his Programmed Article Transfer, paving the way for the first industrial robot in the US.
	1955
	Allen Newell and Herbert Simon develop the Logical Theorist, now considered to be the first artificial intelligence programme.

In the near term – say, five years – he sees DeepMind's work "making our everyday tools more smart and adaptive". "Better search, so it understands your context and intent better – you could be more ambiguous and it will understand what you're trying to do. Smartphone assistants are pretty limited in how they work as they're programmed. Wouldn't it be great if they could learn to adapt? You'd say, 'I want an amazing trip round Europe, book me all the hotels and restaurants and flights,' and it would know the archaeological sites, would take you via a vineyard if wine's your thing. Or, 'I'm moving to a new city, I've got small kids, what area should I look for with decent Ofsted reports?' That's the sort of tech I'd hope to see embedded in lots of places in five years. Reinforcement learning will be as big as deep learning is now – the decision-making part of our algorithms, working out the best action to take, which works initially by trial and error. Trading would be big – anywhere you have sequential decision-making tasks. We were talking to a weather company about the data they're collecting – trying to detect the pattern for climate modelling. Predictive analytics will be huge – you'll see this learning adaptable intelligence seeping into different products."

And after? "Algorithms will be as good as radiographers at looking at scans – some aspects of those tasks will be augmented by AI. Ten years-plus, it's the AI scientist. And maybe there'll be an AI listed among the authors of a *Nature* paper. That will be pretty cool."

Demis Hassabis was four when he became curious about the chess game his father and uncle were playing. His father, a Greek Cypriot singer-songwriter who once ran a Finchley Central toy shop with Demis's Chinese Singaporean mother, humoured him and let him play; within two weeks the boy was beating the adults. At five he was competing nationally; at six he won the London under-eight championships; at nine he was captaining England's under-11 team – when England was second in the world to the Soviet Union. "I was an introspective thoughtful child, I guess, always trying to work things out," he recalls. "You can't help asking, how's my brain coming up with these moves? You start thinking about thinking."

Aged eight, he bought his first computer – a ZX Spectrum – with £200 prize money from beating his American opponent, Alex Chang, 3:1 in a four-game match. "The

amazing thing about computers in those days is you could just start programming them. I'd go with my dad to Foyles, and sit in the computer-programming department to learn how to give myself infinite lives in games. I intuitively understood that this was a magical device which you could unleash your creativity on."

His father began home-educating him while his mother worked in John Lewis. Then, aged 11, at the local comprehensive, Christ's College Finchley, he discovered AI after buying himself a Commodore Amiga to program games. "I wrote AI opponents for *Othello*, as chess was too complicated for the machine to run, and it beat my younger brother." By 13, he was the world's second-highest-rated chess player for his age after Hungarian grandmaster Judit Polgár. Within a year he'd decided that computers were more interesting than

'CLIMATE, DISEASE... AI-ASSISTED SCIENCE WILL HELP THE DISCOVERY PROCESS'

chess. He completed his GCSEs by 14, took maths A level at 15, and further maths, physics and chemistry at 16, and applied to Cambridge after seeing a Jeff Goldblum movie, *The Race for the Double Helix*, about the discovery of DNA. "I thought, is this what goes on at Cambridge? You go there and you invent DNA in the pub? Wow."

His school hadn't sent anyone to Oxbridge for years, and Hassabis, 15, was not prepared for the Queens' College interview. "It was really cold. The professor was asking a question about computer science. If I wanted to visit all 30 colleges, he asked, what's the standard path? I said 30 factorial. Then he said, 'So what is that, then?' I was like, what? How am I supposed to calculate 30 factorial? I came out

with the answer immediately: 10 to the 25th – not that far from the actual answer. He was totally taken aback. He'd just wanted me to say, 'It's a very big number.' I didn't tell him how I did it. I was bored in an A-level maths class, and was playing to work out the shortest number that would break my scientific calculator. Turned out to be 60 factorial. I used that to estimate what 30 factorial was."

He won his place to read computer science, but Cambridge wouldn't let him start at 16. He had come second in a games competition in *Amiga Power* magazine and won a job at Bullfrog Productions, Peter Molyneux's development house, where he spent his year off. Aged 17, he wrote a multi-million-selling game called *Theme Park*, "cementing my view that AI

(Opening spread) Demis Hassabis at the DeepMind HQ in London **(below)**

would be this incredible advance" and making him enough money to finance university. On graduating with a double first, he joined Molyneux's new company, Lionhead Studios, where he was lead AI programmer for *Black & White*. A year later, he started his own studio, Elixir, which grew to 60 people. "I wanted to create a political simulator, *Republic*, where you had to overthrow the dictator by any means. We simulated a whole country, a million people. It took five years – we were too ahead of our time."

Hassabis decided to take a PhD in cognitive neuroscience at University College London, focusing on memory and imagination. "I thought that would be a good thing to study because computers do episodic memory badly. My work was investigating imagination as a process – how do we visualise the future?" He tested the imagination of amnesiac patients

with a damaged hippocampus and found that their descriptions of, say, being on a beach were impoverished, suggesting that the hippocampus incorporated a visualisation engine. His published paper was listed by *Science* as one of the top ten breakthroughs of 2007. He then studied computational neuroscience at UCL's Gatsby Computational Neuroscience Unit, with stints as a visiting researcher at MIT and Harvard. By now, he also held a record as five-times winner of the Mind Sports Olympiad.

When in 2011 Hassabis was ready to launch DeepMind, he knew he wanted funding from Peter Thiel, Facebook's initial lead investor. Trouble is, he didn't know how to reach Thiel. "It took me a year to work out that I'd need to give a talk at one of the AI conferences he was sponsoring, at which there would be a speaker event where I'd probably have a one-minute



chance to pitch him,” he recalls. He researched Thiel and found that he too played chess. “So I thought that would be a more interesting ‘in’ than being the hundredth person pitching to him. I not so subtly weaved into the conversation a question about why chess had survived so successfully. He was intrigued. The reason, I said, was that the knight and the bishop are perfectly balanced, causing all the creative asymmetric tension. He said, ‘Why don’t you come back the next day and do a proper pitch?’”

Thiel invested; so did Elon Musk, Skype cofounder Jaan Tallinn, and Li Ka-shing’s Horizons Ventures. Antoine Blondeau, cofounder of Sentient, an AI startup which has raised \$143 million, was asked by Horizons to investigate DeepMind. “They impressed us with their laser focus on solving a complex scientific problem in an agile, pragmatic way,” he says. “And we liked the quality of the group.” It was Musk who told Larry Page about this company trying to crack AGI. A couple of months later, Alan Eustace, Google’s senior VP of knowledge, emailed to suggest a meeting with Page. “It’s not the sort of invitation you turn down,” Hassabis says. “It took a year [of negotiations]. One reason we chose Google was culturally we were a good fit, but also AI is something Larry passionately cares about.”

But why did he sell? “We weren’t planning to, but three years in, focused on fundraising, I had only ten per cent of my time for research,” he says. “I realised that there’s maybe not enough time in one lifetime to both build a Google-sized company and solve AI. Would I be happier looking back on building a multi-billion business or helping solve intelligence? It was an easy choice. And there was something Larry said to me: ‘I spent 15 years building Google – why don’t you just come and take advantage of the opportunity we’ve built here?’ I didn’t have a good answer to that.”

There were questions, even among its investors, over whether yet another

‘AN INVITATION FROM GOOGLE IS NOT THE SORT YOU TURN DOWN’

1956

John McCarthy coins the term “artificial intelligence” at a conference at Dartmouth College, New Hampshire.

1970

Patrick Winston builds ARCH, a program that can learn concepts based on examples in children’s books.

1959

IBM’s Arthur Samuel builds a computer draughts game that learns from its mistakes, plays at master’s level and beats the Connecticut state champion.

1994

Autonomous robot cars VaMP and VITA-2 take passengers for a 1,000km drive around busy Paris streets at up to 130kph.

1966

The Stanford Research Institute builds the first mobile robot to perceive and model its environment. The bot, called Shakey, is shut down five years later.

2001

US spy plane Global Hawk charts its own course across 13,000km between California and South Australia, completing the first non-stop flight across the Pacific by an unmanned aircraft.

097

London startup was selling out too soon. Hassabis dismisses this notion as “silly”. “People should be caring about where is the work being done. We have full control of what we work on. Google is investing in the UK – that’s brilliant for UK science. Who owns the company is neither here nor there. And we’re a research company.

“I also want to show that this is a more efficient way of doing science. There have been Bell Labs and Xerox PARC and Microsoft Research – but they’ve been run more like academic departments. This is hybrid. All the great advances will come when two worlds merge, whether neuroscience and machine learning, or academic thinking and startup thinking, combined within a big company.”

It was non-negotiable that DeepMind would stay in London. Partly because it offers a talent advantage: “If you’ve

got a PhD in physics from Cambridge and want to do some world-changing technology, there aren’t that many options here – in Silicon Valley there are thousands. And if you’re focusing on a long-term goal, the Valley can be a bubble – people trying to create the next *Snapchat* every five minutes. There can be a lot of noise in the system.”



t 11, Mustafa Suleyman was buying Irn Bru bars and Refreshers wholesale at 7½p a pack and selling them at Queen Elizabeth’s School, Barnet, for 25p. The venture was profitable – until teachers closed it down. Suleyman won a Young Enterprise award for borrowing hospital wheelchairs to create a guide to London for young disabled people. He’d grown up best friends with Demis Hassabis’s younger brother, but was more motivated by social impact than business. “Demis and I had conversations about how to impact the world, and he’d argue that we need to build these grand simulations that one day will model all the complex dynamics of our financial systems and solve our toughest social problems. I’d say we have to engage with the real world today.”

Suleyman, the son of a Syrian-born taxi-driver father and English nurse, won a place at Oxford to read philosophy and theology, but dropped out in the second year, and instead helped start the Muslim Youth Helpline. At 22, he went to work for London mayor Ken Livingstone, advising on human rights policy, but found that government wasn’t the vehicle to promote radical systemic change. He had always been the “well-spoken interlocutor” at home, helping parse his father’s broken English. As DeepMind’s 30-year-old head of applied AI, he’s responsible for integrating the company’s technology across Google’s products – and ensuring clear communication among the top engineers.

So how is Google starting to apply DeepMind’s research? “I’ve got five

teams, working on YouTube, search, health, natural-language understanding and some Google X projects,” Suleyman says. “We’re working at applying the core engine that sits behind the Atari games player across the company. One is in YouTube-recommendation personalisation. We try to learn from the types of videos that lots of users are watching in aggregate to better recommend at the right time, in the right place, what they’d like. Then search: think of search as a process of querying an engine, browsing through links generated, then refining your query in this iterative feedback cycle. Over time we can improve results.”

DeepMind is under no pressure to help Google boost advertising revenues. “There was never any expectation we’d do that – we’re a long-term research effort,” Suleyman says. “Think of deep learning as one of the first steps on the way to building general-purpose learning systems. If we just search for solutions involving products we can imagine today, we’re constraining the limits of our imagination.”

Projects include natural language understanding, boosted by DeepMind’s recent acquisition of Oxford University spin-off companies Dark Blue Labs and Vision Factory: “We’re using neural methods to see if we can create very large machine reading systems without any hand coding,” Suleyman says.

He is also focusing on health. “Preventative medicine is the area I’m most excited about. There’s huge potential for our methods to improve the way we make sense of data.”

Suleyman has a final role: overseeing “ethics and safety” at DeepMind.



On November 2014, Elon Musk submitted a (subsequently deleted) comment to Edge.org: “The pace of progress in artificial intelligence (I’m not referring to narrow AI) is incredibly fast. Unless you have direct exposure to groups like DeepMind, you have no idea how fast – it is growing at a pace close





Mustafa Suleyman, DeepMind's head of applied AI

to exponential. The risk of something seriously dangerous happening is in the five-year time frame. Ten years at most. This is not a case of crying wolf about something I don't understand. I am not alone in thinking we should be worried. The leading AI companies have taken great steps to ensure safety. They recognise the danger, but believe that they can shape and control the digital superintelligences and prevent bad ones from escaping into the internet. That remains to be seen..."

Musk had previously issued a warning that AI was "potentially more dangerous than nukes" and of "summoning the demon". He had also explained that his DeepMind investment was not to make money but purely "to keep an eye on what's going on with artificial intelligence".

Last May, Stephen Hawking, too, referenced the movie *Transcendence* to warn that dismissing highly intelligent machines as mere science fiction "would be a mistake, and potentially our worst mistake in history. One can imagine such technology outsmarting financial markets, out-inventing human researchers, out-manipulating human leaders, and developing weapons we cannot even understand." Apple cofounder Steve Wozniak has also voiced concerns recently.

Jaan Tallinn, the Skype cofounder who was an early DeepMind investor, was instrumental in establishing an independent advisory committee on ethics. "The main reason I backed DeepMind was strategic: I see my role as bridging the AI research and AI safety communities," Tallinn says. "Google and DeepMind agreed to set up an ethics and safety board as part of the acquisition. An important conference earlier this year demonstrated remarkable consensus about long-term issues in AI impacts, culminating in an open letter plus an associated research programme through the Future of Life Institute that Elon Musk backed with a \$10 million

[£6.6m] donation." Musk, Hawking and DeepMind's founders signed the letter.

Suleyman warns that "getting caught up in the language of existential risk" is mere speculation when DeepMind's focus is on designing systems which are narrow and applied. "The AI' is a sci-fi-inspired meme which is not helpful," he says. "We're not building AIs that will be equal to us - they'll help us speak naturally and ask questions directly to a Google search engine. We would certainly be against any kind of autonomous tool of war that could wander round taking kill decisions. That's why we've kickstarted this conversation. Constraining the capacities of our systems is really central."

Hassabis is more direct. "There's a lot of unsubstantiated hype from people who are smart in their own domains but don't work on AI," he says. "Elon tends to shoot from the hip sometimes. I don't think getting hysterical is a good way of stimulating healthy debate - you end up with unnecessary fearmongering." As for Hawking and Wozniak, "These are people who are not actually building something, so they're talking from philosophical and science-fiction worries, with almost no knowledge about what these capabilities can do."

So there's no risk of agents having moral autonomy? "Of course we can stop it - we're designing these things," Hassabis sighs impatiently. "Obviously we don't want those things to happen. We've ruled out using our technology in any military or intelligence applications. What's the alternative scenario? A moratorium on all AI work? What else can I say except extremely well-intentioned, intelligent, thoughtful people want to create something that could have incredible powers of good for society, and you're telling me there's people who don't work on these things and don't fully understand. I wouldn't purport to lecture Stephen Hawking on black holes - I've watched *Interstellar*, but I don't know about black body radiation to the extent that I should be pontificating to the press about it."

Other AI practitioners also see the debate as misjudged. Andrew Ng, who founded Google's first deep-learning team and now runs research at Baidu, sees talk of an AI "superintelligence" as a distraction. "There's a real risk of technology creating unemployment. And there's a big difference between intelligence and sentience. Our machines are becoming more intelligent. But this does not mean that they are becoming sentient. Most AI researchers don't see it as realistic for machines to become sentient any time soon."



hane Legg was failing at primary school and his teachers wanted to keep him back a year. Aged nine, although he had begun to program his Dick Smith VZ200 computer, he could barely read or spell. His concerned parents in the small New Zealand city of Rotorua sent him to an educational psychologist. "I distinctly remember getting to the



2011

Apple launches smart assistant Siri, an SRI International Artificial Intelligence Centre spin-out project.

2015

The DeepMind computer learns how to play 49 Atari games, and is better at some than professional human players.

end of the intelligence test, and the psychologist was quite annoyed, telling my mother, 'What the hell's going on here? This is a ridiculous waste of time.'

"The psychologist took a deep breath, and said, 'He doesn't have a limited intelligence. In fact, I can't measure his intelligence - it's off the chart. I thought, oh really? Because I was used to being the dumb child.'"

Legg was diagnosed with dyslexia and trained to use a keyboard; soon he was in his school's top one per cent. "I started developing games that would beat friends at chess, teaching myself at Rotorua public library. In *Encyclopedia Britannica*, there was an article on alpha-beta search. I thought, I could use that to program chess. I was 12."

Legg studied complexity theory at university in New Zealand, and took a PhD at IDSIA in Switzerland, focusing on how to measure machine intelligence. He then wanted to learn neuro-

science, which brought him to the Gatsby Computational Neuroscience Unit at UCL - where he first met Demis Hassabis. Over lunch they decided it was the right time, in 2011, to start a business. Legg would be chief scientist.

"We'd turn up at conferences, say we're a small company trying to solve AI and people laughed at us," Legg recalls. "But one in ten would say, that's really cool. And as we'd get top researchers joining, credibility grew."

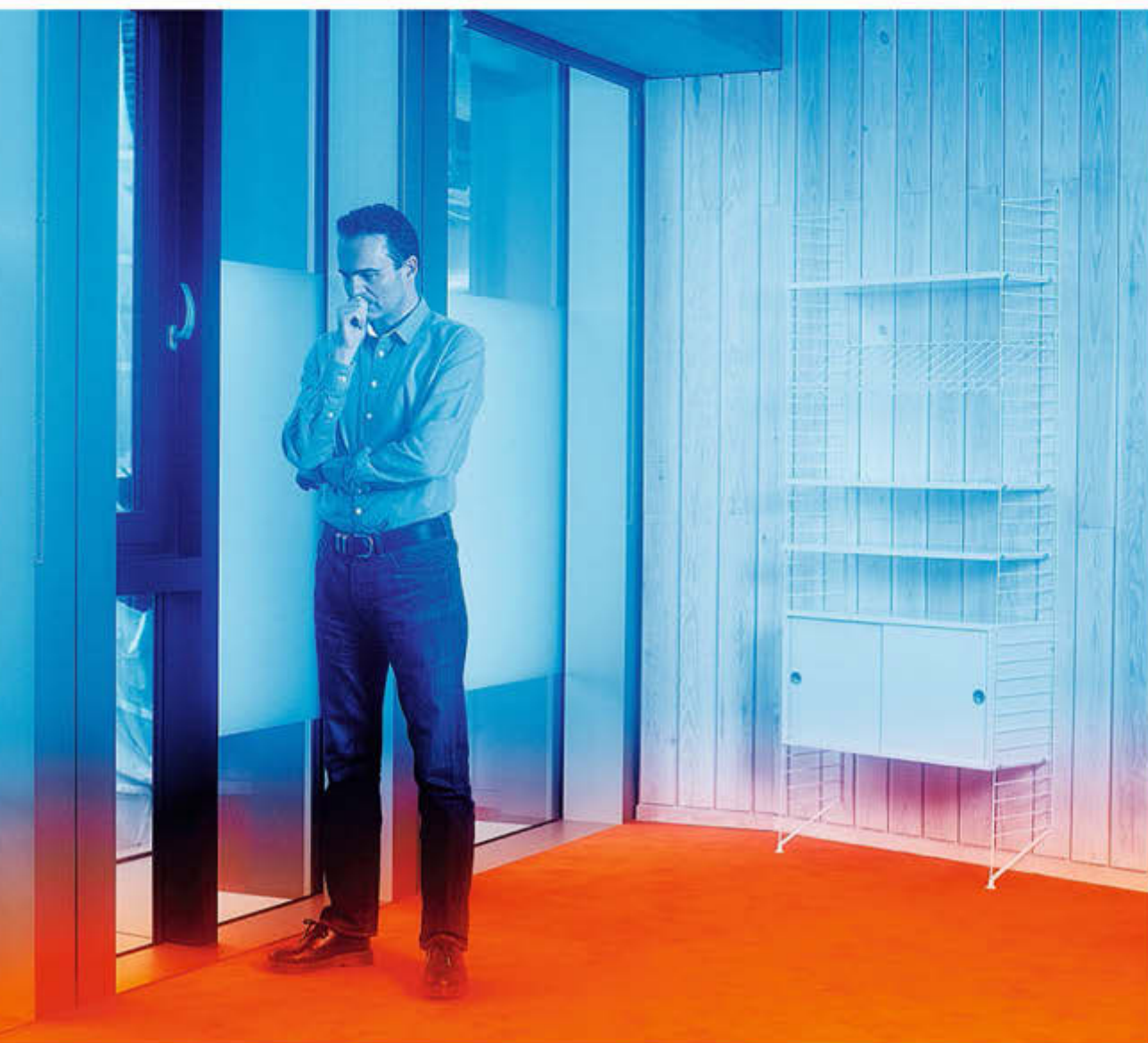
Today, behind King's Cross station in rooms named after Alan Turing, Leonardo da Vinci and Nikola Tesla, the DeepMind team quietly computes and prioritises its way along a 20-year roadmap. And where will we be in 20 years? A scenario like that of the movie *Her*, in which the lead character falls in love with his computer's Siri-like

Shane Legg, cofounder and chief scientist at DeepMind

operating system? "That's science fiction," says Legg, 41. "Will we get there one day? I hope so. But most AIs may not be so human-like. Language is quite a sophisticated thing. Think of it as we're trying to build insects. Years from now, you might get to a mouse. Our systems are very good at *Space Invaders*, they can play *Breakout*, but they're struggling with *Pac-Man*. There's a long gap from here to having a system where you can sit and debate philosophy."

Hassabis agrees. "We're decades away from anything that's nearing human-level general intelligence. But we're going to have systems doing useful things in five or ten years. We're on the first rung of the ladder. As to how many rungs there are - there could be ten or 20 more breakthroughs before we've solved what intelligence is." ■

David Rowan is editor of WIRED. He wrote about Tony Fadell in 07.14



DEAR PRIME MINISTER,

**WELL DONE
ON CLINCHING
THE TOP JOB.
NOW, IF YOU'RE
STUCK FOR
IDEAS ON WHAT
TO DO NEXT,
WIRED HAS
DONE SOME
THINKING...**



BRITAIN REBOOTED



EDUCATION

MAKE UK SCHOOLS LIKE EINSTEIN'S 'GYMNASIUM'

BY **PIPPA MALMGREN**

The UK needs to change its education system so that scientists understand more about the humanities. Nothing has changed since 1959, when CP Snow gave his famous lecture about what he called the “two cultures” (the sciences and the humanities) and their continuing mutual incomprehension.

We spend a lot of time trying to get kids into tech and STEM. We spend hardly any time trying to get poetry and literature into techies. But this matters. As the owner of a robotics

company, I know that most of the parts we use in our drones arrive in a box with absolutely no instructions or explanation. Either you speak the language of the techies who make these electrical and motor parts or you are lost before the box is even open. This suits my business, because otherwise many more people would figure out how to construct drones. But, as an economist, I want to see more competition, more innovation and more inclusion. I want the techies to speak in English as much I believe that we should all learn code. Users should learn geek-speak and techies should learn user-talk.

Why are techies so disdainful of those who don't speak their language? Maybe it's hubris, the confidence that what you are doing is unquestioningly good for humanity. Elon Musk and Steve Jobs could never have conjured their big, Earth-shattering ideas without hubris. But, as President Kennedy said (with a little help from the poet Robert Frost), “When power leads man toward arrogance, poetry reminds him of his limitations. When power narrows the area of man's concern, poetry reminds him of the richness and diversity of existence.”

This is as true for the person in the lab as it is for the person in the Oval Office. According to management guru Peter Drucker: “Discover where your intellectual arrogance is causing disabling ignorance and overcome it. Far too many people – especially people with great expertise in one area – are contemptuous of knowledge in other areas or believe that being bright is a substitute for knowledge. First-rate engineers, for instance, tend to take pride in not knowing anything about people.”

Einstein spoke both languages. He was educated in the so-called “gymnasium” system of German secondary schools, institutions that operated on the assumption that truly educated people needed to know the third law of thermodynamics and also be able to identify and be moved by opera. The UK's education policy today should draw on this idea, just as CP Snow suggested nearly 60 years ago. It's not enough to write code; you also have to have compassion for the person who is trying to use it.

Pippa Malmgren is a former presidential adviser to George W Bush and founder of DRPM Group and H Robotics

We need to look at the

technology industry and see what lessons we can take from the rest of the world to build something of sustainable value to this country. My one piece of advice? Don't try to emulate Silicon Valley.

I've visited countries, regions and cities that have a stated ambition to be the "new Silicon Valley". Often there is even a clichéd name attached to the initiative, like Silicon Roundabout, Silicon Welly or Silicon Wadi. But beyond the catchy names, do we really want to recreate Silicon Valley? There are three strong reasons not to go down this path: risks, context and balance.

In a keynote at South By Southwest 2015, prominent investor Bill Gurley pointed out the inherent high risks of Silicon Valley's current investment model. Gurley identified the number of startups being funded with no revenue, little idea of product direction, and high outgoings. Not only are these startups receiving funding, they are doing so at increasingly stratospheric valuations.

Beyond the financial sense of emulating Silicon Valley there is a stronger reason not to do so: context. Silicon Valley is an incredible place but it was created through the mixing of some unique traits. The availability of land, the high level of research undertaken within the university community, the large talent pool from which to find employees. All these attributes, and others, created specific conditions. Trying to recreate that would be similar to trying to move biology across ecosystems. It would be like attempting to grow a tropical flower in the Sahara.

The final reason not to try to recreate Silicon Valley is one of balance. Silicon Valley just isn't a nice place to work, characterised as it is with clogged roads, strip malls, characterless office buildings and long work hours. Move to

San Francisco for culture and urban amenities and you'll encounter protests about gentrification and newly minted tech millionaires buying up real estate, forcing out existing residents.

The UK is very different. For one thing, it's located close to mainland Europe, a market almost forgotten by most Silicon Valley vendors. But it speaks the same language as the US. That is a combination that can be leveraged to create a different sort of ecosystem. For instance, the presence of world-class creatives, plus London's position as a hub of global capital that attracts a large, highly mobile international workforce working in a wide number of economic sectors offers real opportunity. The government should think about what the UK fundamentally is, rather than trying to shoehorn it into someone else's model.

Silicon Valley is an exciting place to visit, but it is unique, flawed and inimitable. In the same way that the markets of Marrakech lose something when they're populated by Starbucks, we should look to build technology ecosystems in context. By trying to mimic the culture and way of life of somewhere else, we create a situation which is dangerous, damaging and, frankly, sad.

Ben Kepes is a technology evangelist and investor. diversity.net.nz

STOP THE SILICON IMPLANTS

BY **BEN KEPES**



The way we buy and sell electricity is no longer suitable for a world of declining resources. Instead of receiving power from big companies, we should create a system whereby every citizen has a stake in the amount of energy the country uses. And we can do

Leila Madrone is CEO of Sunfolding

this by making citizens providers of energy.

The UK is one of the biggest solar producers, but government policies discourage citizens from producing their own energy. Two simple actions could change this.

First, in exchange for allowing their homes to be on the grid, give households solar panels – and offer

a reward if owners use less than they produce. Second, install a smart meter in every home: access to information is key. Without it, there's no basis for change.

Often, the benefits of solar look attractive to only a small portion of the population. Instead, make it rewarding – and everyone will want to become an energy producer.

ENERGY

MAKE CITIZENS ENERGY PROVIDERS – NOT JUST CONSUMERS

BY **LEILA MADRONE**

ENVIRONMENT

BOOST AGRICULTURE WITH BIG DATA

BY RICHARD TIFFIN

The UK should invest much more in agricultural R&D if it is to guarantee its food security. Productivity in UK agriculture has been relatively static for the last ten years. The easy wins in agricultural R&D have been found. Now, just as the green revolution was based on a change in plant genetics, a new data-led revolution is needed to ensure that productivity continues to grow in a sustainable and resilient way. The government's £160-million agri-tech strategy is a start, but much more money and support will be needed to train tomorrow's food and agricultural scientists and to ensure that the very best science reaches the market.

The UK's food security needs to be considered in a global context – we won't be able to do it on our own. By 2050 the world's population is estimated to increase from seven billion to nine billion. If we are unable to meet the food demands of the population, the resultant social and political instability will be significant.

For the UK to play its part, raising productivity here is both an opportunity and an imperative. We need to build on the advances we have made in precision agriculture and use big data better to improve yields. But we also need to research a better understanding of the connections between farmed and natural ecosystems, which will allow natural resilience to contribute to food-system resilience. Only that way will the UK preserve its own food security and contribute to the rest of the world's.

Richard Tiffin is director of the Centre for Food Security at the University of Reading

Most industries are experiencing a data-led analytics revolution. Commerce has undergone a transformation based on analytics optimisation, data fusion and machine learning. Government needs to follow suit. Whitehall departments have mountains of data but they still prefer the certainties of their current practices. Their view is that if you hide your data, no one will see your inefficiencies. To correct this and start a real data revolution we need to do four things:

1. KILL THE LAWYERS

I have sat in Whitehall meetings where great ideas about using data to save people's lives or create efficiencies have been smothered by lawyers. They say we won't know who owns the data. They say we can't trust "ordinary" people with knowledge. But ordinary people find extraordinary solutions better than hidebound government departments do.

GOVERNANCE

SET DATA FREE FROM WHITEHALL

BY MIKE LYNCH

2. KILL THE DATA LIBRARIANS

Data librarians want to keep data in vaults. They waste endless hours cleaning it, admiring it, binding it and cataloguing it. None of this is necessary. It just keeps data away from where it can be used.

3. KILL THE IT CONSULTANTS

IT consultants tell people that without them they cannot function. For them, nothing can be done because it's too complex for people to understand – and must be kept complex so no one understands. IT isn't a dark art. Open it up and we can all be part of this revolution.

Mike Lynch

is the cofounder of Autonomy and founder of Invoke Capital

4. GIVE THE MEANS OF PRODUCTION TO THE PEOPLE

Government doesn't have the resources or creativity to drive these changes. We need to let outsiders do that after throwing open the data vaults. Real-time traffic data, linked with data from traffic-management technology and GPS systems, could have a dramatic effect on congestion. This will have an effect on the health of both citizens and of the planet.

In healthcare, we're entering a phase where advances in genetic sequencing, lifestyle recording and big data mean that understanding certain cancers, personalised diseases and finding appropriate treatments are becoming a reality. Currently NHS and social-care data is siloed, never to meet; what happened before admissions and after are a data chasm away. Data can save lives.

Free up the government data and hand it now to people who can make a difference.



SUBSIDISE PEOPLE WHOSE JOBS THE ROBOTS STEAL

BY **FEDERICO PISTONO**

We need to change the way we work and the value that we place on jobs. Researchers, including Carl Frey and Michael Osborne at the Oxford Martin School, and Erik Brynjolfsson and Andrew McAfee at MIT, are warning that machines will take many of the tasks currently done by both blue- and white-collar workers. Frey and Osborne suggest that, within two decades, almost half of all jobs will be wholly or partly automated.

This will also be a problem for governments, as employment and GDP growth are currently key indicators of a government's success. If machines do our jobs – and, as Brynjolfsson and McAfee suggest, there will not be enough new jobs for humans – GDP growth may continue but unemployment would rise.

One option is to reduce the statutory working week. In 2010, the UK-based New Economics Foundation laid out a proposal for a 21-hour week. As well as spreading jobs more widely, the report suggests that “this could address a range of urgent, interlinked problems: overwork, over-consumption, low well-being, entrenched inequalities and the lack of time to care for

each other and simply to enjoy life.” Data from the Gallup World Poll and the OECD shows that those that work few hours have the highest quality of life. It's an indication of how entrenched our old ways of working are that we still haven't taken this seriously.

In a world where machines do much of the work, income will go to those who own them and employees' wages will fall. To maintain our standard of living, we will need to separate income from labour. The UK should start experimenting with an unconditional basic income (UBI), which would give a fixed income to every citizen every month, with no strings attached. Citizens would be taxed on any income made on top of that. This would be controversial – it would be easy to attack the scheme as paying people to do nothing – but it may be the only alternative to large-scale unemployment.

UBIs have already been trialled in Canada, Kenya and India, where, according to research by Guy Standing at the University of London,

they have improved almost every significant social indicator. Children's health has improved, indebtedness fallen and, perhaps surprisingly, recipients are three times more likely to start a new business. Next year, Switzerland will decide whether or not to introduce a UBI that would give every Swiss citizen CHF2,500 (£1,760) per month. According to the Citizen Income Trust, a UK UBI of £284 pcm would cost £276bn a year, just £1bn more than the welfare budget. Bolder plans can be made, considering the many billions that would be saved in bureaucracy and making benefit fraud a thing of the past, not to mention all the positive externalities.

Automation has long promised increased productivity, a better quality of life, less use of natural resources and more free time. This has not come to fruition because our economic system is based on the cycle of labour-for-income, income-for-survival and conspicuous consumption. Technology now gives us the opportunity to break that cycle – with a shorter working week and an unconditional basic income.

Federico Pistono, author of *Why Robots Will Steal Your Job – But That's OK*, is a computer scientist and social activist. federicopistono.org

In the digital age, every company is a media company and everybody with access to the internet is a journalist and pundit. In this landscape, how can we legislate for and police defamation? What we need to see from any reform is a clear and precise definition of what it means to defame. And legislation should reflect the reality of how we communicate: online. At the moment, defamation law provides a defence to websites receiving claims for content posted by users, but it is too slow to cope with the speed of online exchanges. The tension between freedom of speech and the right not to be defamed has always been tricky, and we should be cautious about censorship. However, society is not enriched by anonymous trolling, causing upset, damaging reputations and, in extreme cases, putting people in physical danger.

There are no easy answers to this problem, but to maintain reliance on the judiciary, who cannot realistically be expected to keep pace with a fast-changing digital reality, does not bode well for victims. Rather, we need more cooperation, perhaps in the form of a commission which opens dialogue between government and key parties, including print and web press, service providers and even those firms creating social technologies.

Gregor Pryor is a partner at law firm Reed Smith

REVISE DEFAMATION LAWS FOR THE SOCIAL-MEDIA AGE

BY **GREGOR PRYOR**



ENVIRONMENT

USE

GEOTHERMAL

ENERGY

BY ÓLAFUR RAGNAR GRÍMSSON

Heat energy under the ground – geothermal energy – is everywhere in the world, be it London, Manchester or in my country, Iceland. It's only a question of technology, of how you access that heat and for what purpose. If you look at the energy requirements of a country such as Britain, a formidable part is for heating and cooling buildings. We now have a technology that allows us to solve that problem using local geothermal resources that provide sufficient low-temperature energy. If you want to produce electricity, then you need high-temperature areas such as we have in Iceland. But if you just want to heat and cool buildings, you have the resource under every house in the UK.

There are people in central London who have built these house-based geothermal heating and cooling systems in their homes. Although the initial cost is relatively high, after ten years, they will run it for free. You can learn from the Icelandic example and transform the heating and cooling of cities from fossil fuels to these locally based geothermal resources. You do it house by house, street by street, district by district, town by town.

Iceland's route towards renewable-energy self-sufficiency involved using geothermal resources first to heat towns and cities with urban heating systems. That was 30 years ago. Iceland is now the number-one country in terms of renewable-energy usage for all electricity production and all urban and rural heating systems. One Icelandic company, Reykjavik Geothermal, drilled in the outskirts of Abu Dhabi city and found there were sufficient resources in the desert to cool their buildings. You should remember that about 40 per cent of the energy requirement in Abu Dhabi is actually for air conditioning. If Iceland can work with Abu Dhabi – and China and others – on building a renewable-energy future, it's a very strong signal that the playing field is changing fundamentally. If the UK does it incrementally it can, over a reasonably short time, transform one city after another.

Ólafur Ragnar Grímsson is the fifth president of Iceland

SECURITY

STOP OUR SPIES FROM SPYING ON US

BY **CORY
DOCTOROW**

The security services must switch from cyber offence to cyber defence and make our computers secure, even against our own spies. The UK's security services spend millions finding vulnerabilities (known as "0-days") in the computing systems used by government, businesses and residents, and then keeping their discoveries a secret. The result is that all our computing is compromised.

Security services use their knowledge of 0-days against the state's enemies. This allows them to infect computers, hijack network switches and otherwise disrupt anyone they view as a threat, both foreign and domestic. This makes the spies' job easier, but it is wrong to use the money we give them to protect us. And worse, even if citizens are comfortable with their own security services spying on them, any vulnerability left intact is a vulnerability that can be exploited by everyone else.

This matters to everyone in the UK. A house is a computer you live in. A car is a computer you drive. A hearing aid is a computer in your head. If the security services maintain their practice of keeping bugs in our systems secret and unfixed, citizens become vulnerable to attacks through the computers woven into their lives. If we are not allowed to know about the bugs in our mobile's OS, we can never be sure that a crook, foreign spy or voyeur isn't watching us through its camera and listening to us through its mic.

David Cameron promised to end our access to working cryptography if he won the election, because he wanted to be sure that criminals don't have a "means of communication we cannot read". He was wrong. Any encrypted message that our spies can read can also be read by cybercriminals, vandals and wrongdoers. We need to reverse this policy and give UK citizens secure computing that can't be broken into by anyone.

Cory Doctorow is a blogger, journalist and sci-fi writer

INFRASTRUCTURE

CONNECT OUR CITIES

BY **MARK VAN RIJMENAM**

The UK can now learn from them and establish its own truly smart cities. And it really only takes four simple steps:

1. Establish a network of sensors across each city.
2. Provide a robust Wi-Fi infrastructure to connect them.
3. Set up a monitoring system for the data.

4. Share this data with anyone who can use it to stimulate innovation.

Britain has shown it can do this in public transport. Now it needs to take smartness city-wide. Steps 1-3 are engineering challenges. And the UK has plenty of talent to exploit the fourth.

The city of the future is a connected one. Sensors will change the way we live and work by generating masses of data that will create huge economic value for cities and countries. Consulting-engineering firm Arup estimates the global smart-cities industry will grow to \$400 billion (£270bn) by 2020. The UK can't afford to miss this opportunity.

In 2013, the UK government launched Smart Cities Forum, an initiative with the aim of developing a more sustainable future for British cities. National government can provide the infrastructure but it will be local government working with local businesses that will make cities truly smart.

Perhaps the best known smart city is Songdo

in Korea, where almost everything, from the streets to the bins, is equipped with sensors. The data these sensors produce is used to constantly improve the city. Santander, in northern Spain, has installed 12,000 sensors across the city to measure air pollution, help locate parking spaces and to inform rubbish collectors which containers are full.

Mark van Rijmenam, founder of Dataflog.com, is author of *Think Bigger: Developing a Successful Big Data Strategy for Your Business*

SHAME THE TAX DODGERS

BY JENNIFER JACQUET

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The UK already uses online shaming in sophisticated ways to collect revenue: the state publishes the names of those who deliberately default on their taxes. Although Britain leads the US in addressing tax evasion, there are three policies in California (which also publishes the names of tax delinquents) that the UK might consider. The number of people or businesses on the UK list appears arbitrary, and UK law allows the

names to be listed only for a few months. In California, the policy is to list the top 500, which offers clarity. California also ranks offenders, highlighting the worst transgressions. The UK list is unranked.

The other piece of innovative thinking is reporting the amount of recovered tax dollars since listing began in 2007: \$405 million (£270m), against an annual cost of \$130,000. Even opponents of state-shaming find the approach palatable.

A complete transparency policy, would expose all tax delinquents, even those who owe very little. Setting a threshold – in the UK, only those who owe more than £25,000; in California, the figure's \$250,000 – focuses attention on the main wrongdoers, while protecting those unable to pay. It's important to note the effectiveness of the policy tends to be the threat – most people pay up when they are warned they are to be added to the list.

Over the past decade the government has released large amounts of data under the premise that sunlight is the best disinfectant. The next decade of the 21st century will be about shaming – focusing attention on the most egregious and significant offenders. Sunlight can be illuminating, but sometimes a spotlight is more effective.



Jennifer Jacquet is an assistant professor at New York University and the author of *Is Shame Necessary? New Uses for an Old Tool* (Penguin)

You are about to be visited by the shop stewards of the innovation trades union movement, among them university vice chancellors, research scientists, technology entrepreneurs and venture capitalists, each claiming that they hold the key to economic dynamism. You should ignore them, at least for the moment, so you can work out what and who government innovation policy should be for.

The short answer is that you should focus resolutely on the needs of the squeezed middle classes. They are working harder than ever to see their disposable income barely rise. Many fear their children will be worse off than them. For example, creating a decent, national, living wage – or, more radically, a universal

basic income of the kind being debated in Switzerland – would be one of the best ways to underpin the incomes and so the buying power of the squeezed middle.

In Germany's greenest city, Freiburg, for example, the best-insulated apartments cost €50 a year to heat, thanks to mainly local, renewable-energy sources.

When I spent last summer talking to London families getting by on a household income of £33,000, many made a little go a long way, by, say, turning to the sharing economy for what they need – such as a car – without owning it, and by renting out idle assets to make a little extra. Many are now augmenting their earnings in the Uber and Airbnb economy.

You need to jump start this by setting out a different story of innovation. Current disruption can be quite unpleasant if you have few opportunities to find alternative employment with similar wages and benefits.

The innovative, hi-tech sectors need a generative story of socially useful innovation, which creates new jobs and augments existing ones, while using new technologies to solve median-

income households problems such as the rising costs of energy, housing, transport, health and childcare.

So what should you do? Focus on making life affordable for families. Create a prize of up to £5m for someone to come up with the equivalent of Airbnb to increase the availability of flexible, high-quality, affordable childcare. Create government-backed Granny Loans, like ultra-low-cost student loans, for grandparents to spend on childcare, education and transport for grandchildren. Create a volunteering programme, so that if older members of a family, parents or grandparents volunteer, then the children get free access to local leisure facilities such as swimming pools. ■

Charles Leadbetter advises companies, cities and governments on innovation. He is the author of several books, including *The Frugal Innovator* (Palgrave Macmillan)

APPOINT A MINISTER FOR INNOVATION

BY CHARLES LEADBETTER





SERVER IN THE CLOUDS

✕ More than 600 firms
now build drones.
Can Airware be the
operating system to
connect them all?

✕
By Tom Vanderbilt
Photography: Chris Crisman



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A Delta Drone
Delta H with an
Airware Flight
Core autopilot



ONATHAN DOWNEY WAS BORN WITH FLYING IN HIS BONES. HIS MOTHER

had met his flight-instructor father as a student and, as a young child, Downey would accompany his dad on trips. Downey logged his first flight when he was 14 and completed his training while studying engineering at Massachusetts Institute of Technology (MIT). His grandfather was a pilot; an uncle was shot down in the second world war. He has worked at Boeing, but also captained a commuter air service operating from Las Vegas, which ferried tourists on a 19-passenger twin turbo-prop plane.

So there is a touch of irony when, seated across from WIRED at a conference table, he slides over a small red box of machined aluminium. "You're actually one of the first people to see this," says Downey who, at 31, retains the boyishly fresh-faced, lithe appearance of the cross-country runner he once was. This "flight core", as it is called, represents the culmination of his work in aerospace and engineering. Its ultimate function, however, is to eliminate pilot operation from a flying device in which the pilot has already been removed. This little box represents a new kind of dominion of the skies, not of man's conquest of the physics of flight, but man's ability to turn the air into a data layer – to put cloud computing literally into the clouds.

Downey is the founder and CEO of Airware, a three-year-old startup that aims to bring a standardised operating system to the nascent but sprawling world of commercial unmanned aerial vehicles. "What you need is a platform," Downey says, "that bridges a large set of applications and a large set of drone manufacturers." Airware tracks more than 600 drone manufacturers which use the devices in a broad range of applications, from automated aerial inspections of power lines, to delivering medicines to remote clinics, to monitoring the health of a winery's grape stock.

But getting each of those drones to do each of those things requires costly, time-consuming "integration", as it is called – a raft of custom software and hardware solutions. One drone needs to fly at high altitude for hours; another needs to be carried by a utility worker in a backpack; one will carry a motion-stabilised Hollywood camera to film a high-speed chase; another will sport a methane detector for analysing the gaseous plume emanating from a landfill.

"That kind of stovepipe way of doing things isn't going to scale," Downey says, from the company's headquarters on the edge of San Francisco's SoMa neighbourhood. Instead, he envisions Airware as a Wintel for drones. Intel, he says, "didn't build all the computer systems, they built a key hardware component that all of the hardware manufacturers needed". It will also, Downey believes, provide a regulation-compliant, data-rich platform to help assuage insurers with qualms about the notion of automated, "beyond-line-of-sight" drones operating in the public domain. "One company told us they're only able to write a policy for one in 50 companies that approaches them," Downey says. "Right now, they're not able to get the flight data that they need."

The idea for Airware was born, he says, when he led an MIT team building a drone for an inter-collegiate competition. Drones had to autonomously complete a number of missions. Downey says the first question to answer was: "What was going to be the brain of the drones?" At the high end, a would-be drone builder could turn to software and electronics that had been developed for military UAVs. "Every one of them was a black

box," Downey says. "It did seven things, but if you wanted to do something different, your hands were tied."

At the other end of the spectrum was the world of open-source code. "We found that this was spaghetti code – not architected to allow extension by other people," Downey says. The team struggled for two years, only to finish second from last. His takeaway: "Building all the underlying pieces was really a distraction from what the drone was supposed to do."

Downey eventually moved on to the Advanced Systems group at Boeing, where he worked on a really big drone: the A160T Hummingbird, a 2,900kg autonomous helicopter designed to fly for 24 hours with a 4,000km range. While working on the project, Downey heard a common refrain from drone-makers who had previously worked with the military. Now they were getting requests for drones that could survey and map, or inspect crops. "They said 'We're trying to repurpose this black box solution and it's not working,' or 'We tried the open source and we crashed all our drones.'"

So Downey, with a group of colleagues from Boeing and investment of \$25 million (£16m), founded Airware. Big aerospace it is not – on the day WIRED visits, a number of fixed-wing drones are collecting GPS signals in a small car park next to the office. Most of the company's staff are software engineers, and much of what they think about is processing data. In the world of drone 2.0, the focus is no longer on how drones fly, but on the information they collect. "It's all about the data," says Lucas van Oostrum, chief technology officer and cofounder of the Dutch drone builder (and Airware customer) Aerialtronics. "Drones are flying servers."





Jonathan Downey
with a cutaway of
UASUSA's Tempest

HOW TO USE YOUR DRONE

1 HURRICANE HUNTING

Nasa, Northrop Grumman and the US National Oceanic and Atmospheric Administration are working to send drones into the heart of storms.

2 PEST CONTROL

The Dehogaflier drone, built by Cy Brown and James Palmer of Louisiana Hog Control, uses a heat-sensing camera to locate crop-ruining feral pigs.

3 SPORTS PHOTOGRAPHY

A drone provides an otherwise unobtainable angle. UAV tech company Falkor Systems focuses on sports such as skiing and base jumping.

4 WILDLIFE PROTECTION

The United States Geological Survey is using a metre-long, camera-equipped drone to monitor the endangered sandhill crane while nesting.

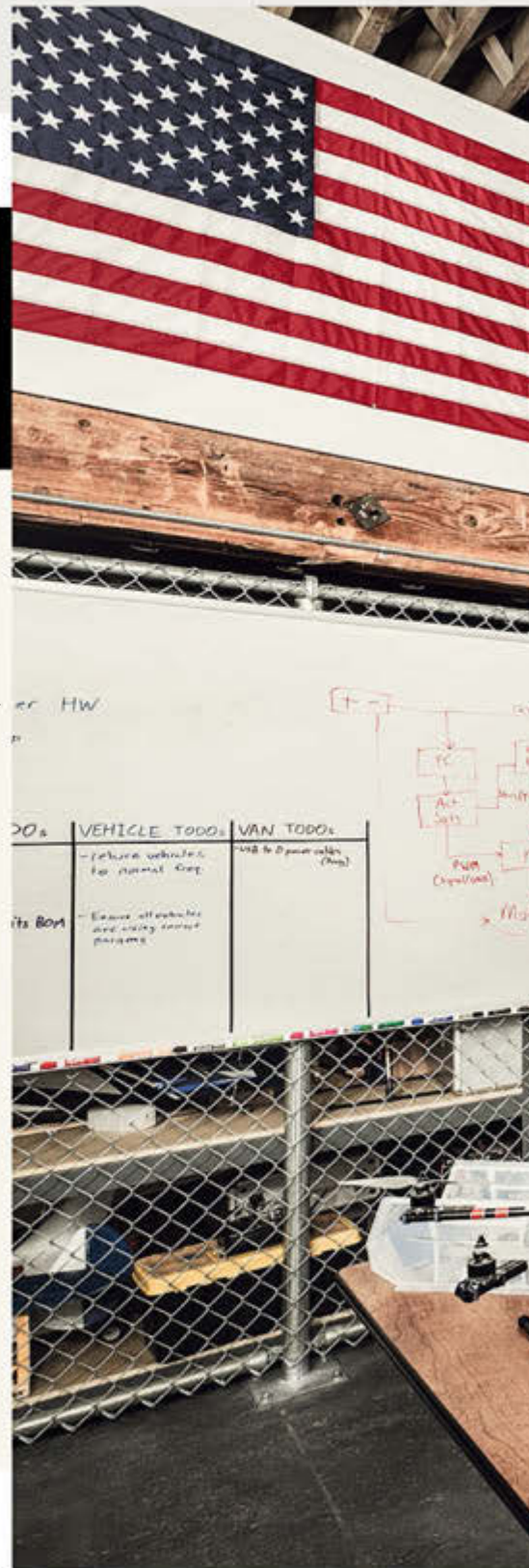
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FEW YEARS AGO, JOSHUA KORNOFF, president of Allied Drones, got a call from the producers of a National Geographic documentary. They wanted an aerial shot in a US national park and were unable to get permission. "It was a really dry season up there, and they were afraid of sparking a forest fire," Kornoff says. Officials were also concerned about the noise generated by a full-sized aircraft. Kornoff's career had been spent in film special effects and pyrotechnics. "I spent 15 years in Hollywood blowing things up for the movies," he says. UAVs were just beginning to hit the commercial market, so Kornoff modded up a drone and got the shot. Soon he started getting calls for other jobs, but had no appetite for being on set. Then he had another idea: "We'll just build for everyone else." Allied Drones was born.

Drones have fast become standard Hollywood tools – one of the more high-profile drone-filmed sequences was 007 chasing a villain across the rooftops of Istanbul in *Skyfall*. Given that technical hurdles are now relatively low ("It's just a flying camera," Kornoff says), Allied Drones is working on more specialised applications. This has meant building drones for clients' specific needs, from mining operators to a healthcare provider looking to create an air link between far-flung clinics in developing countries. As Kornoff began to grapple with the difficulty of building bespoke drone after bespoke drone, he began to see patterns in what customers wanted. "After a while I said, 'If I could standardise something that would satisfy 95 per cent of your needs, you guys would deal with it.'" With the addition of Airware's flight controller, he is able, as he puts it, "to integrate a standardised autopilot on a standardised air frame that's still highly adaptable". It can scale.

HEAVY DUTY: ALLIED DRONES

The California-based company builds drones for a wide range of applications, ranging from filming equipment to checkpoint security. The HV44 "Hornetcam" is sturdy enough to perform infrastructure work, and the battery-operated EF44 "Atlas" is adept at mapping and data gathering. To allow all the airframes to work on a single platform, president Joshua Kornoff plans to equip each drone with Airware's operating system. His easily transportable drones are built to lift heavy loads and travel long distances; the tethered HV44 is capable of hovering continuously for over 72 hours.





**"THIS IS SIMPLY THE DEMOCRATISATION OF THE TOOLS OF HOLLYWOOD:
BOOMS, CRANES AND HELICOPTERS" - CHRIS ANDERSON, 3D ROBOTICS**

 Airware engineers
work on the Allied
Drones EF44 UAV



AERIALTRONICS: THE DUTCH DRONE MASTER

Led by Lucas van Oostrum, this Dutch company was established in 2011. Its core product is the Altura Zenith, which can fly for up to 45 minutes, is controlled by a tablet and can lift almost 3kg. Belgium's federal police are turning the Altura Zenith drone into a permanent member of its team to assist with detective work, following 70 UAV test missions over two years. And in Norway, the Zenith – with its optical and thermal cameras – has been used in an avalanche search-and-rescue exercise. The test, in which 250 people participated, was carried out in conditions involving a wind chill of -15°C and 3m of snow.

Below: Aerialtronics' Altura Zentith ATX8 eight-prop drone



Airware UAV systems engineer Stefan Aprodu tests Drone America's DAX8

Bringing this kind of automation to drones may not seem as revolutionary as something like Google's self-driving car project, Downey says, because progress is incremental. Some communication drones, for example, require two operators. "One's acting as a pilot and the other is kind of looking at the data coming in from the drone. With automation, the footprint is down from two to one."

But there is another benefit. "If aviation has taught us anything over the past 40 or 50 years, it's that we've been able to decrease the rate of accidents by orders of magnitude through greater software automation," Downey says. That includes standardisation: "Pilots doing the same thing in the same way every time." Automated drones can bring not only more safety to previously risky manned flights, they can lessen the risk for humans doing dangerous jobs. In 2013, for example, 13 workers fell to their deaths in the US alone while carrying out mobile tower inspections. In the Netherlands, Aerialtronic's Lucas van Oostrum notes, T-Mobile inspects towers using his company's drones.

At a typical Dutch football stadium, "they would take a cherry picker and it would take them two to three weeks to do all the inspections [of towers]," says van Oostrum. "With our drone they can manage to do it in a bit over three hours, with huge cost savings and not putting anyone in harm's way." And drone work is not all visual. "We had a client who had this lighting collider, the size of a quarter," says van Oostrum. "To test if it works, you need to touch it."

Payloads are also a possibility: van Oostrum has been contacted by an Antwerp diamond dealer to discuss the feasibility of carrying diamonds from the exchange to the airport. "They have to put a lot of security on the ground," he says. "It won't happen today. But in two years?"

Typically, drone applications still involve a fair amount of manual operation, he says. "They fly it on GPS - all the little corrections are made manually." But van Oostrum's drones will be carrying increased on-board computing power in the form of a processor called Nucleo, running algorithms that can identify mobile towers and parse important information from the irrelevant, "like your neighbour sunbathing on the roof". An increasing amount of the data processing will be happening on the drone itself. "Why are on-board calculations so important? Because you're limited in the bandwidth on your downlink." The Nucleo, he notes, "can do the processing and then give flight commands to Airware".

The idea of having a single solution that can create a sort of jack-of-all drones is what drew a recent investment in Airware by GE Ventures, the strategic investment arm of General Electric (GE). As Alex Tepper, GE Ventures' managing director, describes it, he was part of a team looking to develop "robotic solutions that will be able to work collaboratively with humans in the field." With UAVs, he says, "there are going to be a hell of a lot of solutions... a lot of them are going to be sort of kluged together to solve something." Their relationship is already bearing fruit: in April, Airware announced GE as "enterprise customer" for Aerial Information Platform, its operating system for commercial drones.

Airware, Tepper says, is "product agnostic", allowing a customer to "develop customer-oriented vertically oriented business software into it". Some of that will be vertical - having quadcopters fly up and down a wind turbine, for instance. Others will be horizontal. "The way oil pipeline inspection is done right now is typically with a Cessna or a helicopter,"



Tepper says. The sensor? "There is literally a guy looking out," he says, searching for right-of-way encroachments, or checking that a riverbed hasn't eroded away the pipe's support. Lower-cost automated drones could vastly increase the scale and frequency of coverage.

In Airware's lab, John Kolaczynski, the company's director of customer implementation, demonstrates the ease of the process. Airware's PC interface simply requires customers to describe the desired vehicle, payload and mission. The operator uses drop-down menus to choose what he wants to happen in the event of what Kolaczynski calls "off-nominal events". If your drone goes astray, for example, do you want it to return home and land? The company is still learning what can be off-nominal in the real world. Testing an anti-poaching drone over several weeks in Kenya's Ol Pejeta Conservancy, three Airware technicians ran sensor-equipped UAVs across the huge 360km² park, trying to locate where animals were each day.

"You would spot a herd of elephants," Kolaczynski says, "and when they drank water, their trunks would turn a different colour." It is not hard to see the benefit of automated drones doing daily aerial sweeps. There was just one problem. "There wasn't a lot of infrastructure out there, so we had our ground-control system hooked up to a generator." One day, workers were cutting the grass, for the first time that summer. "And they ran over the Ethernet cord." The connection to the drone was lost, but the vehicle found its way home.

**'AIRWARE'S SENSOR-EQUIPPED
ANTI-POACHING DRONE SPOTTED
A HERD OF ELEPHANTS IN KENYA.
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WOULD CHANGE COLOUR'**

- JOHN KOLACZYNSKI, AIRWARE



THE AUTOMATED DRONE IS ALREADY

available to the high-street consumer. One afternoon, standing on the Berkeley rooftop of 3D Robotics (3DR), Chris Anderson, CEO of the world's third-largest producer of drones (and a former editor-in-chief of WIRED US), sets one of his company's sub-\$1,000 drones equipped with a GoPro camera. He then takes an Android phone out of his pocket, pulls up an aerial photo of our location and taps the image of the adjacent cement factory ("They're friends of ours," he says). The drone rises from the roof and heads for the building. Once there, it dips on its side to capture the imagery, and circles the building. It rises another five metres and does it again.

"It's doing feature recognition between those two circles," Anderson says, "and using the parallax effect to get 3D images." Its imaging completed, the drone swoops over our heads and gently lowers itself to within a few metres of its launch position. Back in the office, Anderson syncs the data to Autodesk, and shortly afterwards has a fairly detailed ground-up rendering of the plant. The drone is no longer just a flying vehicle, but an automated, Android-powered aerial 3D scanner.

Even as drones prepare to go to work, we are still in the experimental stage. This is captured in a video clip Anderson shows WIRED of Richard Branson kitesurfing off his private Caribbean island. The entrepreneur carries a smartphone that acts as a homing beacon for the 3DR drone that follows behind, filming his exploits. "This is simply the democratisation of the tools of Hollywood," Anderson says. We are in a renaissance of personal storytelling. And now, he says, we have access to the one thing only Hollywood used to have: "booms, cranes and helicopters".

There will no doubt be a point where a superabundance of drones hovering over a hipster event becomes the aerial

equivalent of the selfie stick, noxious and requiring legal (or social) regulation. But for now, the consumer drone market operates quite unfettered, restricted largely by rules set in place for radio-controlled aeroplanes. This freedom is in contrast with the commercial drone market, which in the UK is regulated by the Civil Aviation Authority – in October 2014 it revealed that there were 359 operators licensed to use sub-20kg drones for work purposes. As of April 2015, 246 companies were legally entitled to fly drones in the US. In France, as of March 2015, 2,000 operators have been granted permission.

Drone pilots, as Airware's head of regulatory affairs Jesse Kalman notes, need to be trained pilots. "Being able to fly a Cessna is no benefit," he says. "But they want to know you know concepts of airspace."

"My children can fly drones," Anderson says, "but trained professionals cannot." He argues that all this open-source innovation is where the action is, even commercially. The rail giant Burlington Northern Santa Fe Railway, for example, has been granted drone permission from the Federal Aviation Authority after citing 3DR as one of its favoured vehicles. As the commercial drone market has stalled while awaiting regulatory approval, innovation has come from below. "It is always going to be essentially an outgrowth of consumer vehicles

– cheap, small, easy to use, with computer vision and sense-and-avoid technology, but costs \$500 and they are here today," Anderson says.

At Airware, Downey argues that while on the consumer end, much of the competition is driven by price. "A lot of the end users of drones in our scenario are making \$10,000 per day per drone. Our customers aren't focused on the upfront cost of the system. We are optimising for compliance, meeting insurance requirements."

Allied Drone's Kornoff is more blunt: "It's almost like comparing a pickup truck and an industrial mining dump truck. They both carry stuff, they both have four wheels." But, he says, one cannot do the job as well as the other. He points to the main electronic power wire used on many consumer drones. "They're using a hobby-grade connector that costs a tenth of a penny. If that fails, the whole aircraft is down." To take flying video shots of a wedding is rewarding, he adds, and "was impossible five years ago. But that kind of stuff is not useful to big corporations."

GE's Tepper says that Airware is trying to occupy the middle ground between military UAVs and "their highly, engineered solutions" and consumer drones, "which don't have the deeper engineering that



THE WORLD'S FIRST SMART DRONE: 3DR ROBOTICS

3D Robotics claims that its Solo is the world's first smart drone. The UAV will travel to whatever distance and altitude is programmed into its dashboard – or

take your selfie. The video-game-style controller and integral flight simulator make it easy to fly while operating a built-in GoPro HERO4. The

company was founded by an unlikely pair: former editor-in-chief of WIRED US, Chris Anderson, and college dropout Jordi Muñoz.

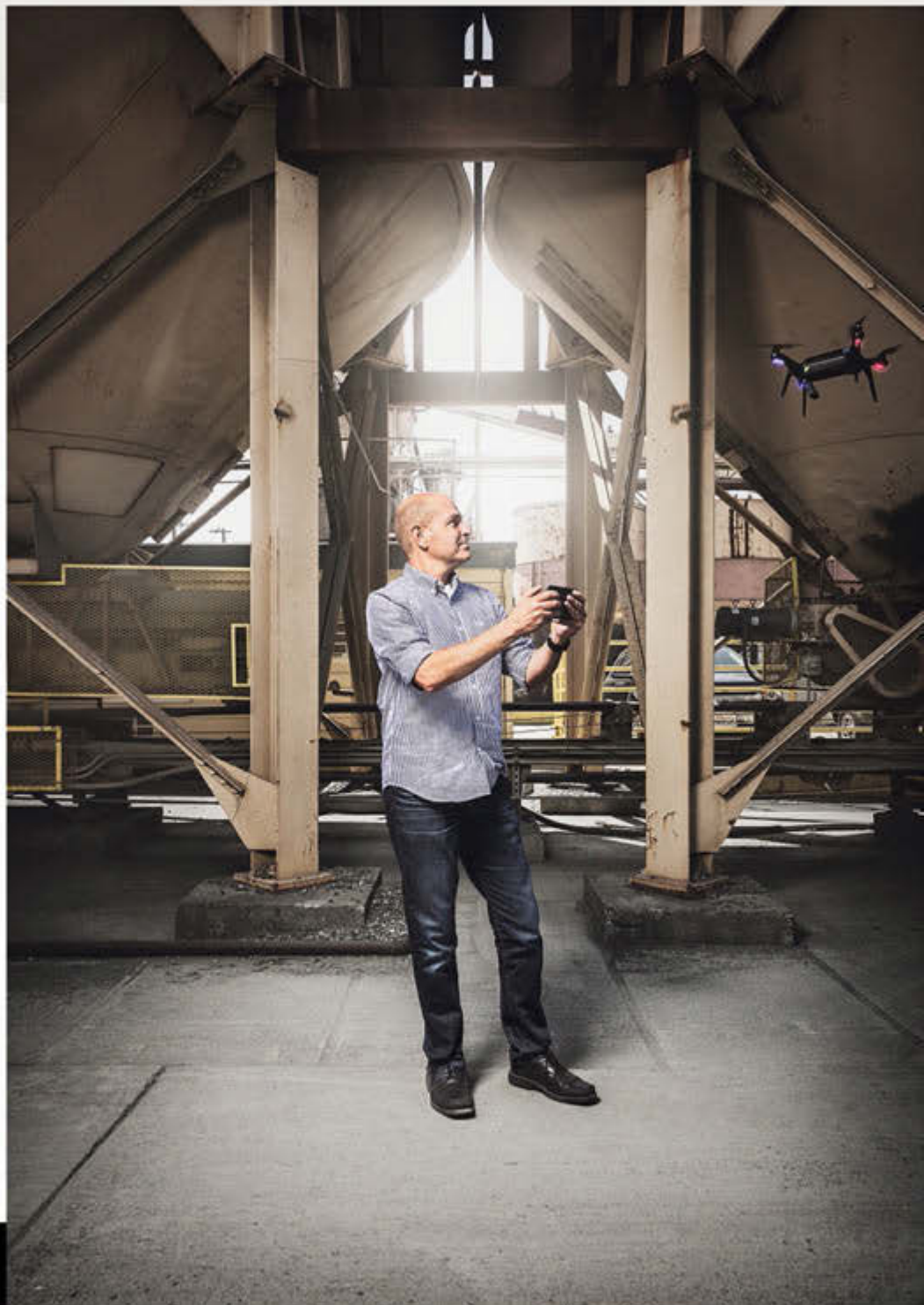
needs to be done for commercial applications, whether it's long endurance or more security". Michael Blades, an analyst with Frost & Sullivan covering the UAV industry, suggests that there will be significant consolidation in what is now a sprawling market - something that has already occurred in military applications, where contractors have snapped up autopilot solutions. "It's like the internet in the early days - there were a million Amazon-type websites to buy from," Blades says.

Downey agrees that anyone leveraging the Airware platform will have a similar experience in terms of reliability and the features on offer, but adds that "we are actively enabling companies to create their own intellectual property as a software application or as a compatible piece of third-party hardware. We're enabling companies to compete with each other."

This doesn't sound like a pilot talking. Downey's mission has moved beyond flying to creating plug-and-play aerial computers so that, as he says, "someone just out of high school with minimal training [can operate] the drone very quickly in a reliable and safe way."

Within just a few years drones have gone from top-secret military technology to something that you can order on the internet. As uses for the devices begin to proliferate, they're getting down to work, harvesting data, going from the skies to the cloud. ■

Tom Vanderbilt is a WIRED contributing editor. He wrote about Planet Labs in 05.15



They met through Anderson's open-source robotics development site DIY Drones in 2007, and 3DR's first consumer products - the IRIS and IRIS+.

Introduced in 2014, IRIS+ has a 400g payload capacity, up to 22 minutes of flight time and 3PV Follow Me technology, which allows the pilot to go hands-free

while the drone stays with them. Now, with a \$50 million series C round of venture capital funding led by Qualcomm - and previous investments from

big names such as Richard Branson - 3DR says it is the first company to successfully incorporate smartphone technology into its consumer drones.

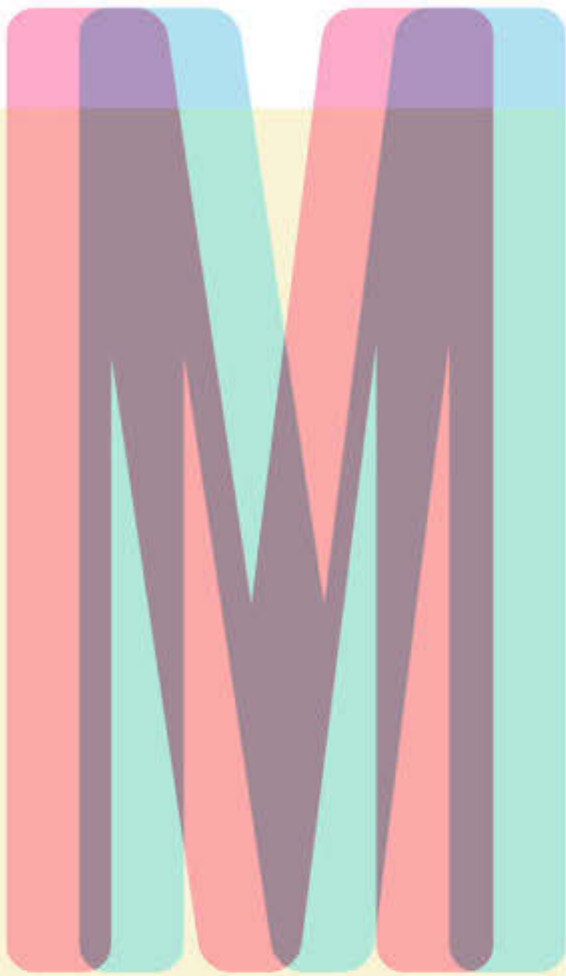


Chris Anderson, founder of 3D Robotics, with a Solo smart drone

TOTAL IMMERSION

VIRTUAL
REALITY IS
ABOUT TO
EXPLODE.
NEW DEVICES
SUCH AS
OCULUS RIFT
AND MAGIC
LEAP WILL
IMPACT NOT
JUST GAMING
- BUT EVERY
SECTOR FROM
EDUCATION
TO MEDICINE





ARCH 2003. INFANTRY PLATOON SERGEANT CHRIS

Merkle and the 43 US marines and medics in his charge are under attack in Nasiriyah, Iraq. “We’re in the back of an open truck with a couple of sandbags. Bullets are flying through the packs and I can see bodies, burning buildings, the people, the carnage, other marines. We’re driving very slowly and getting shot at. I’m returning fire, and going over part of a bridge crossing a river. It’s partially blown out.

“There are bodies everywhere. I see [an enemy combatant] through my rifle scope and we are getting closer, so I try to identify if he is dead. I always told my marines, and myself, don’t look at their faces, but I look right at his face. His lower extremities are completely gone. He’s dead. I scan around. But there’s motion. Maybe someone is hiding behind a vehicle. It’s the man I thought was dead, eyes staring at nowhere. His head lifts and his finger is waving at me. I prepare to engage and stop the threat. I swear he is looking at me. I swear he is shaking his finger, slowly. Do I shoot? I should shoot. Is it the right thing to do? Should I help this person so they are not suffering? Who am I to make this decision? Our vehicle passes. I lose the angle and he’s gone. I hear a shot. The truck behind had seen him too, and made the decision for me.”

Merkle feels the Earth move as rockets devastate nearby buildings; he can hear blades chopping as helicopters hover overhead. But he’s not in the back of a truck in Nasiriyah. More than a decade post-invasion, the 43-year-old is sitting in a specially designed chair in Long Beach, California, at the Veterans Affairs Hospital, holding a fake weapon and telling his therapist about his longest day in Iraq, while he watches it pass by through a virtual reality (VR) headset.

Before he began VR exposure therapy, a system designed by Skip Rizzo at the University of Southern California’s

**Non-gaming
VR applications
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DESIGN**

No 1 3D scanning

In March 2014 St Albans-based visual-arts studio Rewind FX launched a technology to convert photo-realistic scans of properties or locations into a 360° environment when introduced to any VR device.

“The finished product, Hororma, will be near lifelike,” says founder David Black. It has recently been used by Savills estate agents on a house in Weybridge.



SOCIAL

No 2 Virtual cinema

Riftmax Theater, a virtual cinema and a stage for live VR performances, is the centrepiece of what its creators call Internow Games. The virtual world – in which there are six theatre types – can be used to hold public screenings and shows where people can meet and collaborate. Internow has built an editing system users access to create customised environments – and professionals are already experimenting. Tim Wildgoose (an armoury maker and technician for *World War Z* and *Maleficent*) used it to showcase his debut, *Roadside*.

Institute for Creative Technologies (ICT), Merkle was unable to speak about his experience. And he could not remember the man with the waving finger. Talking therapy didn’t work – he found it impossible to shoot the breeze with a stranger, then segue into his nightmares. To this day, he can’t watch films about the war. But encountering virtual reality in the summer of 2013 was “an amazing thing”, he says. “I was so much calmer with the road rage, and my family. It unleashed a lot. I would never have been able to talk like this a year ago.”

When Merkle first came to ICT they asked him to describe a scenario from his time in combat. He chose a day he thought would be easy to handle – not his worst day, but one of his most exhausting, during the initial push into Iraq in 2003. ICT used software to create a basic game-like representation of those events, and then he sat through the finished product nine times over a few months. Little of the detail he described above was in ICT’s simulation; virtual reality helped his mind fill in the blanks, and memories returned. “As you walk through, you talk it through,” he says. “It’s almost like opening a filing cabinet. Suddenly I’d be able to remember names. I’d remember details of what people looked like; what insurgents looked like.”

Merkle’s story is one of thousands from people whose lives are being changed by a new wave of VR applications. Advances in processing power and sensor technology have meant that cost has reduced to a point where it can finally impact multiple industries, and startups are using it in sectors as diverse as entertainment, design, scientific research, defence, communication and education. In healthcare, university labs and private companies are increasingly using it to treat phobias, PTSD, burns and phantom-limb syndrome. Hunter Hoffman and David Patterson, of the University of Washington’s Human Interface Technology Laboratory in Seattle, have been employing VR to distract patients undergoing burn debridement (the removal of unhealthy tissue from a wound). The method has

been found to be as effective at reducing pain as a morphine derivative. It's why, when WIRED asks 13-year-old Diego Rosas from Mexico to describe his wound care when using Hoffman's SnowWorld VR, a cartoonish landscape filled with caverns, penguins and snowmen to launch snowballs at, he replies, "It's very entertaining." Rosas, at Shriners Hospital in Galveston, Texas, had burns covering 86 per cent of his body – 74 per cent of them third degree – after a propane canister exploded. When asked what he thought about while using the VR system during debridement, an excruciating and slow process, he said simply, "Hitting the snowmen."

Consumer versions are due to be released over the next 18 months: VR headsets from Facebook's Oculus Rift, Valve's HTC Vive and Sony's Project Morpheus, along with Microsoft's augmented-reality glasses, HoloLens. Powerful graphics cards mean higher frame rates, bringing an end to the motion sickness experienced by some VR-headset users during the 90s, caused by a lag in gameplay. Improved sensor technology has enabled better low-cost tracking of wearers using devices such as Leap Motion and Kinect, and smartphone technology is the foundation of the Google Cardboard and Samsung Gear VR products – headsets that allow mobile devices to act as virtual-reality screens – which have already been released.

Jaron Lanier, the computer scientist credited with coining the term "virtual reality" in 1980, was running similar experiments 30 years ago. There was, however, one key difference: "We spent literally millions of dollars per setup," he says. "It was such a fortunate, rare and esoteric experience."

In 1983 Lanier established VPL Research to develop, among other things, gestural gloves for Nasa's Ames Research Center in Silicon Valley, and a head-mounted display (HMD), the EyePhone. Lanier says few people ever got to experience the worlds his team created because there was a long product cycle. "I'm hoping to get rid of that [delay] so the experience reaches the consumer," he says. "That's a transition we've never gotten to before, and [now] I think we might be able to get there."

No 3 **Immersive VR education**

A collective of developers in Waterford, Ireland, focuses on putting users in the shoes of historical figures, such as Neil Armstrong. Other experiences being worked on include a medieval village in the grip of the plague, and a conversation with a soldier in the first world war before he goes over the top. Another piece of software, *LectureVR*, teaches the theory of relativity using a representation of Einstein – and atoms and planets materialise around you. "You can be joined by classmates from all over the world and have your tutor log in to answer questions," says software developer Michael Armstrong.



'WE SPENT LITERALLY MILLIONS OF DOLLARS PER SETUP. IT WAS SUCH A FORTUNATE, RARE AND ESOTERIC EXPERIENCE'

This kind of superior virtual reality has been accessible to industry for decades: BAE Systems uses it to design warships, and Ford has its own immersive Vehicle Evaluation (FiVE) Lab. But widespread adoption of VR moved closer when, in 2009, a teenager in Long Beach, California, started working on a device in his parents' garage. Palmer Luckey bought HMDs from government auctions and eBay to solve the lag and tracking problems that dogged the technology. He contacted Mark Bolas, who pioneered VR in the 80s, and, in 2011, Bolas, now director of Mixed Reality Research at ICT, helped Luckey get a job in his lab, where Luckey worked with Rizzo, who needed a cheaper, better-quality HMD for his PTSD research.

That same year Luckey and the ICT team put together a precursor to the Oculus Rift, a mass of wires and clunky headgear that, crucially, had an algorithm that distorted the image so it looked realistic when seen through a lens. The device received \$2.4 million (£1.6m) in Kickstarter funding in 2012, before Facebook bought the company for \$2 billion in March 2014. "We knew this guy had talent and vision for how to create these headsets, and Mark helped him and provided guidance on the open-source design," Rizzo says. "The vision was always there. What we needed was wide-field view, a more comfortable head-mounted display and lower-cost built-in tracking. That's Oculus."

In 1993, Hoffman was using \$90,000 worth of kit to help patients undergoing painful physical therapy, including a computer that weighed 11kg and a 3.5kg helmet. Today, the Oculus Development Kit 2 will set you back \$350. It weighs under 450g and offers 360° tracking, built-in audio and a 100° field of view.



EDUCATION

No 4 **Virtual education**

Tomáš Mariančík, 23, is a self-taught games maker who wants to change the face of education with VR. His platform, Neos VR: World of Comenius, is the beginning of the Czech's educational "infoverse", which he has trialled at the Mendel Grammar School in Opava, Czech Republic, for a class on the body. "Students explored the abilities and interesting features of the virtual world on their own, then shared their discoveries with their peers, confirming the social aspect of the project is an important one," he says.

SOCIAL

No 5 **Virtual worlds** San Francisco-based High Fidelity's 15-strong team includes former staff of NVIDIA and Pixar; founder Philip Rosedale is the brains behind *Second Life*. The startup plans to build a universe of user-generated interconnected virtual worlds using open-source software. "We are using inexpensive webcams and motion controllers to capture gaze, facial expressions and body language," Rosedale says. The result is a "very powerful sense of being present with another person face-to-face in VR".

ENTERTAINMENT



No 6 **VR camera** Jaunt VR sells itself as the full toolset for directors who want to film in VR, providing an omnidirectional camera, ambisonic mics, and post-production editing tools. Founded in 2013, it recently produced a Middle Earth experience in conjunction with Sky ahead of the release of *The Hobbit: The Battle of the Five Armies*, and has worked on a series of films recorded in the Moab Desert and Yosemite National Park for North Face. Some of its first releases included a VR performance of Jack White gigs from Fenway Park, Massachusetts, and Colorado's Red Rocks Amphitheatre.



DEFENCE

No 7 **RAF and Navy training**

The Royal Navy and BAE have used tailored versions of VR company Virtualis's technology to help with the building of ships and submarines, respectively. Lockheed Martin uses the same kit to teach students to fly using its Helicopter Crew Training system at RAF Shawbury and the RAF Search and Rescue Training Unit.

No 8 **Virtual submarine**

Headed by Bob Stone, the University of Birmingham's Human Interface Technologies (HIT) Team has built a VR training simulator for the British Explosive Ordnance Disposal robot vehicle CUTLASS. It's also made a VR tool for the MoD's Defence Science and Technology Lab to evaluate the potential for VR in designing surface and submarine command stations. Other projects include a VR recreation of a village to be used in a counter-IED course for soldiers.

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CULUS IS JUST ONE PIECE OF HARDWARE THAT'S

founded on the work of the pioneers of the 80s and 90s. When Microsoft revealed HoloLens in January 2015, the company described the product as "holographic goggles" that work by directing light particles from a "light engine" through the goggles' two lenses (which house layers of blue, green and red glass), before hitting the back of the eye. Microsoft's presentation focused on everyday tasks; for instance, a virtual electrician hovered in front of users to help them install a light switch. Sony, meanwhile, is aiming its Project Morpheus at gamers – demonstrations focused on sword battles and shark attacks – although the company is also moving into augmented-reality glasses with its multi-purpose SmartEyeglass developer edition priced at £620.

Oculus is open to multiple possibilities. At *Forbes's* Under 30 Summit in October 2014, Luckey predicted his design could affect healthcare, education, architecture and design. Equally, the company behind mysterious "lightweight wearable" Magic Leap – which describes itself as a "cinematic reality" startup – managed to secure \$542 million last year from disparate investors, including Qualcomm and Google, because the technology's uses are not limited to one specific field. Commentators suggest Magic Leap will merge virtual reality and augmented reality, with the company's CEO describing it as "a hardware, software, firmware and development platform". A patent filed by the company in January 2015 describes a lightweight head-mounted display that houses a tiny projector that will project images on to the retina.

In 1984, Lanier predicted that high-quality virtual reality would be readily available by 2020. Today, he muses that this technological advance might have the greatest impact on the mundane aspects of life. "It could be the little things that



really matter to people,” Lanier says. “Remote help or instructions – that stuff might be a lifesaver.” Lanier would also like to see VR applied in education. “My hope, and this goes back to my very earliest motivation, is to create a way of making math real for people, so there isn’t this huge part of the population that finds it this alien thing,” he says.

One self-taught developer, Tomas Mariancik, has already run a successful early demonstration of his software, NeoS VR: World of Comenius, which he describes as an “educational infoverse”, in a Czech school in October 2014. “Imagine sitting in a lecture room with Einstein as he talks about the theory of relativity,” Mariancik predicts. “Now imagine that as you sit in this room, atoms and planets appear in front of you as Einstein is explaining in words the ideas and theories he has so vividly and visually in his mind.”

For Lanier, there’s another important aspect: “The art of it,” he says. “We shouldn’t underestimate how far that can go. That in itself is possibly going to be the most valuable thing to most people.”

IN 1961, A BUDDING CALIFORNIAN film-maker filed patent number US 3050870 A, wedged between US 3050869 A (an “article drying machine”) and US 3050871 A (a “question and hidden answer device”). The applicant, Morton Heilig, described how to build a “simulator apparatus” that could transport users to another world. Heilig imagined a cabinet that would house a 3D “wide-vision” display, vibrating seat and scent maker, all designed to “develop realism in a simulated situation”.

The patent suggests servicemen and factory workers use it to learn hazardous tasks safely, while understaffed schools would teach oversubscribed classes faster. In reality, when the device (which he named Sensorama) was unveiled in 1962, members of the public enjoyed a simulated motorcycle ride through Brooklyn, the waft of fresh pizza and a peep show featuring a belly dancer.

DESIGN

No 9 **Virtual maintenance**

Sheffield University’s Advanced Manufacturing Research Centre (AMRC) works with Boeing to tackle manufacturing problems affecting aerospace companies, SMEs and others. It has delivered a low-cost VR system to a Yorkshire-based manufacturer so, when problems occur, a 3D VR diagnostic can be used to walk customers through the maintenance problem. AMRC’s manager Rab Scott says he plans to make the centre a “national VR resource” for design collaborations.

No 10 **Walk-in architectural models**

Oregon-based startup Arch Virtual offers a way for architects not only to visualise designs, but also find out what the public thinks of them. The company has built a VR experience depicting the newly planned NBA Sacramento Kings Arena. “The application helps players, fans and stakeholders visualise the new facility,” says Arch Virtual founder Jon Brouchoud.

HEALTHCARE

No 11 **Accuracy for training surgeons**

Created by French entrepreneur Rémi Rousseau, Surgevry uses a dual GoPro camera system in conjunction with Samsung Gear VR to capture and play point-of-view operations for trainee surgeons. “Surgical videos suffer from a very small POV that allows you to see the incision but not the precise gesture of the surgeon,” Rousseau says. “With VR, you see both in great quality.” The set-up is also used for getting a close-up of CT scans. Rousseau predicts that it will facilitate anatomy learning.



Few people know of Heilig today; his Sensorama design was too costly to impact cinema and industry in the 60s in the ways he’d envisaged. Nor would they be able to identify the various other pioneering pieces of VR kit created during the decades that followed, including computer scientist Ivan Sutherland’s 1968 periscope-like HMD Sword of Damocles, or even the groundbreaking 150° wide-view Boom built by Mark Bolas in the 80s. VR will become more accessible over the next year, but there are industry veterans who recognise past hype in the excitement of today.

“There are many outfits that had their fingers very badly burned in the first tranche of over-hyped technology and false promises,” says Bob Stone, a 30-year VR veteran and director of the University of Birmingham’s Human Interface Technologies. “My big fear is that there is too much of a ‘cult’ factor at play. We’re still expecting people to wear a cumbersome, low-resolution device, and I don’t care what they say about [Oculus] Crystal DK2 – it is still a fraction of the resolution of the human eye and it does not match its field of view. While we have to wear something, trying to claim we are fully immersed is nonsense.”

His caution is understandable: affordable hardware is almost here, but the key experience that will sway non-believers is always a few steps behind: since software developers are working from prototypes, not finished products, they are continually playing catchup with hardware.

“Right now, we are approaching bubble proportions in the industry, where you see lots of VR hardware getting built, but still we lack killer apps to take advantage of it,” argues Fernando M Tarnogol, founder of PsyTech LLC, which uses VR to treat phobias. “It will be critical to maintain interest in the technology while both sides of the equation get developed,

No 12 Cognitive behavioural therapy

Virtually Better, a team of CBT-trained psychologists in Decatur, Georgia, has built a "phobia suite" to help patients combat their fear of flying, heights, storms and more through exposure therapy. Virtually Better uses tools such as the Unity 3D platform to build immersive environments. "Patients are often surprised by how quickly they get a sense of presence and immersion," says Dawn McDaniel, Virtually Better's VP of research, grants and client services. "It is also less nerve-racking for a patient to try to tackle their fear in a therapist's office using VR than in the real-world with the potential of awkward or embarrassing situations."

SOCIAL

No 13 Virtual friendships Linden Lab's relaunched *Second Life* is now compatible with Oculus Rift's development kit. It will enable users to create their own device-agnostic, complex 3D experiences. CEO Ebbe Altberg claims the quality of the virtual world will be "so good your brain is sufficiently convinced it's real and you emotionally believe the experience... This will empower creators to make virtual experiences that transport users with an emotional impact rivalled only by the real world."



No 14 Prehistoric reconstructions

Launched in July 2014, Alchemy VR has created *First Life*. It explores 500-million-year-old oceans and brings viewers face to face with Earth's first forms of life using CGI reconstructions of fossil studies. It's made David Attenborough's *Great Barrier Reef* (an underwater special) and *Micro Monsters*, which brings the world of insects closer.

No 15 Filming VR New York-based startup Littlstar has built a virtual-reality cinema platform that transfers content from 360° cameras to HMDs, mobile devices and the web. The company's technology adjusts content according to the hardware being used. "We are the only centralised network that is open, has a developer API, and is not tied to any particular piece of hardware," says founder Tony Mugavero. "We're democratising 360° content."

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so I think the next two to three years will be key. VR has already failed once. Another failure, although much more unlikely, will be a huge setback for widespread adoption."

Despite these concerns, there remains a genuine enthusiasm among those building this generation's HMDs - Oculus, Sony and Microsoft are all excited to see others working in the field, and are open to collaboration. "I've done things at Bafta with people working on VR, and you forget who works for whom because you just really want to talk about it," says Dave Ranyard, director of Sony Computer Entertainment's London Studio. "I really want to try HoloLens, and it's the same every time Oculus brings out a new version. If it was just us doing it, I'd still be passionate. But the fact that more people are involved is brilliant. Two years ago it felt a little bit risky working on this thing with wires everywhere and controllers taped to bicycle helmets. Now it feels like a groundswell."

That groundswell and convergence are starting to become apparent across industries. Ranyard says the next phase of

**'THIS IS AN ETERNAL ADVENTURE,
LEARNING MORE ABOUT HOW
TO PERCEIVE OURSELVES IN THE
WORLD, AND IT NEVER STOPS'**

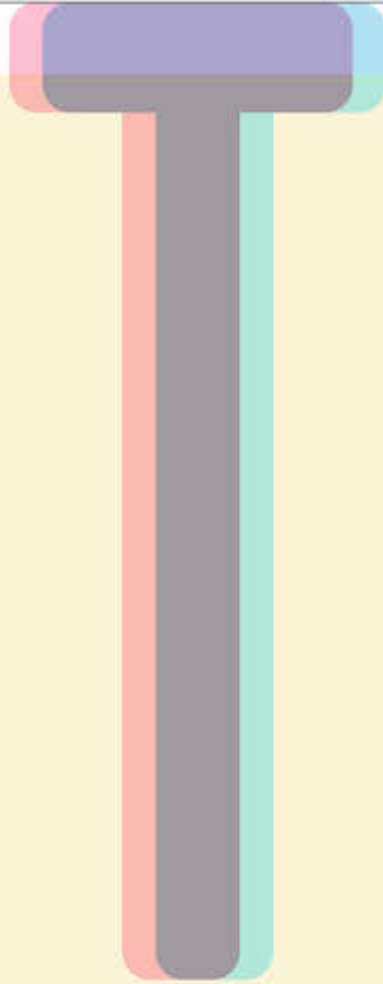
Sony's Project Morpheus R&D centres on human interactions: "a character passing you a note - it sounds trivial, but that's never happened... or someone puts a gun to your head and as you move, they move with you."

Linden Lab founder Philip Rosedale - who in 1999 created *Second Life* - has been working hard to refine the technical detail that will create realism. After leaving Linden Lab, Rosedale went on to found the VR world *High Fidelity* in 2013, raising \$4m from investors including Google Ventures while still in stealth mode. "We've focused initially on face capture and 3D audio and very low latency to create a powerful sense of being present with another person face-to-face in VR," Rosedale says. "That is the demo that blows everyone away... The new hardware will initially create some incredible gaming and entertainment experiences like recorded immersive 3D media. Beyond that, generalised virtual environments will take the lead, bringing a much larger opportunity around shared and social spaces." Investors appear to agree: *High Fidelity* raised a further \$10m in Series B funding in February.

At ICT's HQ in Playa Vista, Rizzo and his team are adding detail to their Afghanistan scenarios, introducing a clinical trial for victims of sexual trauma in the military, and building Strive, a pre-deployment tool that depicts scenes that PTSD sufferers typically report as significant to their trauma. There will be new levels of nuance, sensitivity and detail: biomarkers (such as pulse) are taken to help predict a soldier's resilience to trauma, a tactic the gaming industry might adopt to ensure gamers are entertained, not overwhelmed. Film-makers are already experimenting with this: Oculus's Story Studio, which was unveiled at the 2015 Sundance Film Festival, demonstrated a short film, *Lost*, which modified its length - becoming shorter or longer - according to the viewer's reaction.

No 16

Rediscovering the past
French company Dassault Systèmes has been working with VR in healthcare, design and life sciences since 2002. It has two, million-dollar CAVES, one in Paris, another in Boston. The team has built a 3D experience around French architect Jean-Pierre Houdin's theory of how Egypt's Great Pyramid was built, and partnered with Harvard University to create a virtual reconstruction of the Giza plateau. Its two most recent projects are a recreation of the 1941 attack on Pearl Harbor, and the 17th-century *La Lune* shipwreck off the coast of Toulon.



HERE'S BEEN SIGNIFICANT progress in VR over the past decade, but the products coming to market only hint at the possibilities. What we imagine the future of virtual reality to be in healthcare, defence or entertainment will rapidly become outdated. Lanier argues that this is the nature of VR, because the technology is founded on exploring perception – and our perception is continually changing.

“When a virtual world is fully realistic, you’ll discover that your nervous system has adapted and now there’s a chance to make an even better virtual world,” he says. “That will keep on going.” VR could move in multiple directions with a variety of applications, and the individual is at the centre of that tech in a way they never have been before: the focus is solely on the user’s experience and perception. What works for them – or fails to – will make or break a concept. Michael Armstrong, founder of Internow Games, which makes the cinematic VR platform Riftmax, says he conquered his stage fright using Riftmax, and Linden Lab CEO Ebbe Altberg describes real families being formed offline after their avatars met on his platform. This bleed into the real world extends to people with disabilities – in a virtual environment any movement is possible.

PsyTech’s Tarnogol remembers working with an autistic boy who loved Disney. He would soak up the content but avoid communicating with real people. “To him, I was the Mad Hatter. But what if you could immerse yourself and him in a VR environment, and your avatar was Cinderella?” The boy’s perception of others might change in that moment and possibly affect his perception of what it means to have a relationship with another person.

“Some people think VR is an engineering problem to be solved, and that once we get that, it becomes ubiquitous and ordinary,” Lanier says. “I don’t think that’s what it will be like at all. This is an eternal adventure, learning more about how to perceive ourselves in the world, and it just never stops.”

Liat Clark is deputy editor of wired.co.uk. She wrote about hoverboards in 03.15

JARON LANIER

“My worst fear for ten years from now is that virtual reality has become ordinary and boring. I want it to be something like culture – like cinema, literature or music, where it’s always controversial, always fresh, always renewed, always revolutionary. Always filled with a degree of shock. There’s no such thing as the perfect music that ends it all – it’s a constant, ever-evolving art form because the way we perceive reality is ever evolving. There’s no final version of it. The thing that would really break my heart is if it becomes ordinary and boring. That is something I’d loathe to see and I predict that that will not happen. It will be more like culture and less like infrastructure. Always filled with a degree of shock.”

WHAT'S NEXT FOR VIRTUAL REALITY?

RAB SCOTT

**University of Sheffield
Advanced Manufacturing**

“We need a methodology to display large amounts of structured and filtered data in context. VR is perfect for this.”



TOMAS MARIANCIK

World of Comenius

“You’ll have a single device that you can wear anywhere that will intelligently link the systems around you and project all the information you need.”



FÉLIX LAJEUNESSE

Felix & Paul Studios

“There will be some unlearning and relearning involved. VR will eventually be recognised as a distinct art form, just like music, theatre, cinema or painting.”



EBBE ALTBERG

Linden Lab

“With VR, you can communicate an entire experience that affects a person’s brain. That will change how we communicate, learn, socialise, work, heal, entertain...”



MICHAEL BUCKWALD

Leap Motion

“We are working with multiple VR OEMs to embed our tech within HMDs, and we expect to see the entire motion and gesture-control industry gain traction in 2015.”



PHILIP ROSEDALE

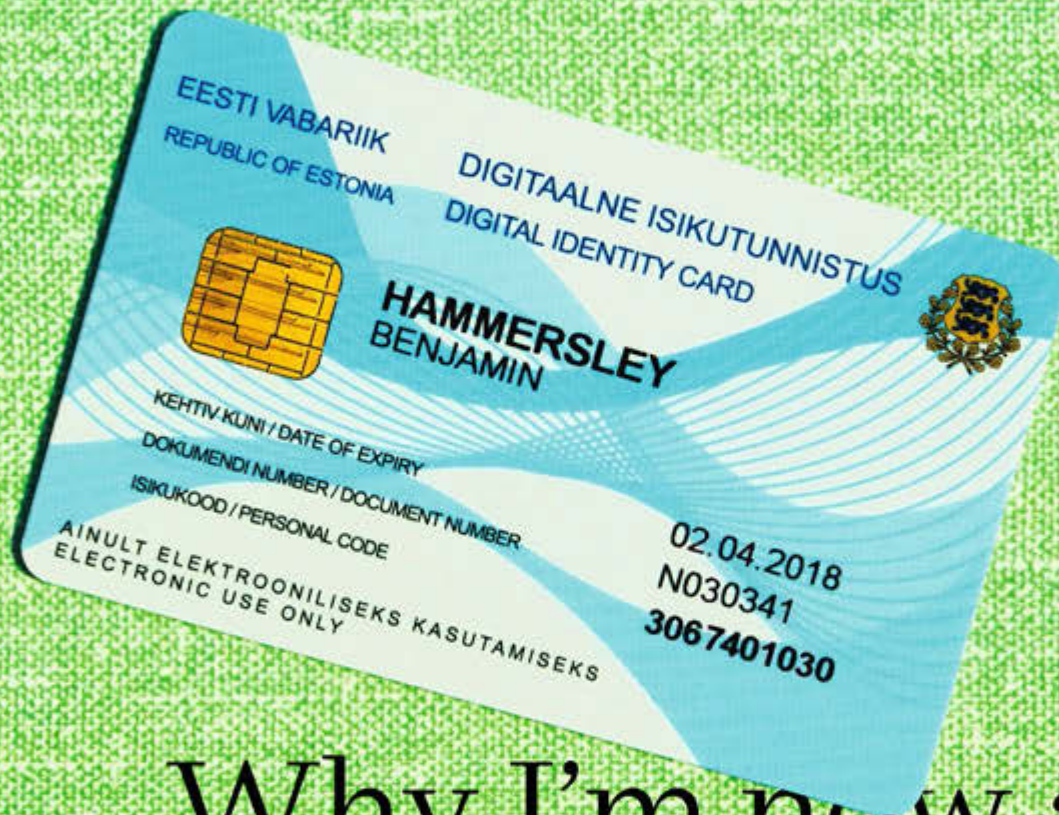
High Fidelity

“The new hardware will create some incredible gaming and entertainment experiences like recorded immersive 3D media. Beyond that? More social uses.”



The most
technologically
savvy nation
in the world is not
in Asia or the
Americas. In fact,
it's a tiny blob
on the Baltic coast.

By Ben Hammersley



Why I'm now an
e-resident of Estonia.
And you
should be too

The most advanced digital society in the world is a former Soviet Republic on the edge of the Baltic Sea.

And by handing over €50 and a photograph, allowing my fingerprints to be taken and waiting a few weeks while my credentials were verified, I have been issued with an identity card, a cryptographic key and a PIN code to access its national systems. I am now an official e-resident of the Republic of Estonia, as is the Japanese prime minister, and you will want to be one, too. And what's more, by doing so, you'll be part of a system that could not only reinvent public services for the internet age, but fundamentally redefine what it means to be a country.

But first, let's back up. When Estonia gained independence from Russia in 1991, it quickly realised that it needed to find something to set itself apart from its neighbours. Norway had oil, Finland mobile phones, Sweden design. But as Taavi Kotka, the Estonian government's chief information officer, asks, what do you think of when you think of Baltic states like Lithuania or Slovenia? Nothing, he says, and so to become distinct, Estonia has embarked on massive technological innovation.

It's hard to see this when you're there. The capital, Tallinn, feels a little battered. Though the oldest parts look like the set of a low-budget *Game of Thrones*, the Soviet breeze-block architecture in the rest of the city reminds visitors just how cold it is in winter. International brands mix with local burger chains with slightly off typography. It doesn't scream San Francisco, put it that way.

But what Estonia has achieved makes the Northern Californians look like laggards: despite only half of the country having a phone line in 1991, by 1997, 97 per cent of Estonian schools were online. In 2000, cabinet meetings went paperless. By 2002, the government had built a free Wi-Fi network that covered most of the populated areas. By 2007, it had introduced e-voting, and by 2012 huge amounts of fibre-optic cabling were being laid – promising ultra-high-speed data connections – and 94 per cent of the country's tax returns were being made online, taking users an average of five minutes to fill in the parts that hadn't been automatically completed by the link between the tax office and local banks. Now, every task that can be done with a digital service, is.

The frost-eaten potholes in front of the shopping mall are deceptive – this is a society that is putting itself above such atoms-based matters. Today, almost all government services are managed online. Citizens, armed with a chip-and-pin identity card, can run their affairs from a laptop or phone, anywhere there is connectivity. And the Estonian government wants to offer you the chance to do the same thing.

From summer 2015, you can go to the nearest Estonian embassy and apply for e-residency. When I made my application, in March 2015, I had to go to a police station in Tallinn and fill in a form in front of a police officer. This will soon be done electronically but, for now, the interface is a real person behind a long row of desks. Applicants take a numbered ticket and wait for an electronic display to change, before sitting at a desk with an official. So many government services are delivered digitally nowadays that the police stations have become more general purpose, with the feeling of an office that'll only be around until the printer ink runs out. You're joined in the queue-gloom by members of the Russian-speaking minority and their children applying for passports or reporting lost ID cards. Giving my personal details, fingerprints and photographs to a uniformed officer of another state – one that was once part of a system that I grew up thinking of as the enemy – I try and do the mental arithmetic about the officer's age. Is this the only uniform she's ever worn? Was she a baddie once?

Twenty-four years after the end of the Soviet Union, this still feels weird. I feed the Estonian system with enough data to prove that I'm who I say I am; there's allegedly a background check and then a few weeks later I get an email telling me to fly back to Tallinn and collect my card. The snow has melted but no one has washed their car yet, and

the old man in the police station – who definitely seems like he might have been a baddie once – hands over a cardboard box. Within is my card, a USB reader, a sealed envelope with my PIN code and an invitation to visit a particular URL. I have become, while only planning a few more hours in the country, an e-resident of Estonia. I feel like saluting.

But back to the idea. You want to open a business, say; once you have your card, you can go online from wherever you are on the planet, log on to the government portal with your card and PIN, and use it to form your Estonian company, then register with an Estonian bank and start trading. Because the Estonian tax office is digitally linked to Estonian banks, filing your taxes is radically simple – remember the five-minute average from a few paragraphs back? So too is any bureau-

cracy involved in keeping the company going. After all, these are Estonian digital services we're talking about: it's across the web, secured with your ID card.

And that's the opportunity, because Estonia is working on linking its tax office with its counterparts in other regions of the world. The Estonians want to offer the option for, say, UK citizens to run their UK companies through the Estonian system, which would in turn, in the background, with no extra work for the user, make sure that the UK tax office receives all the money it is legally due. A UK-based entrepreneur, they hope, will decide to open her business in Estonia, use an Estonian bank and pay for some Estonian services, even if the company was only going to be trading in the UK, because she would find Estonia's national

Many Estonians already believe that Russian intervention is inevitable and are deeply concerned about the ambitions of Vladimir Putin



Ben Hammersley in Tallinn, where he went to collect his Estonian e-residency card in March 2015





Tallinn is a jumble of styles: otherworldly Baltic, Soviet brutalism, shiny ultra-modernity and mid-century kitsch

infrastructure far easier to deal with than the UK's. In other words, a nation is now competing with its neighbours on the basis of the quality of its user interface. Just as you might switch your bank to one with a better mobile app, the Estonians hope you'll switch your business to a country with an infrastructure that is easier to use.

To be clear, this doesn't involve actually becoming Estonian, or even physically being in Estonia. There may be only 1.3 million Estonians, but they're perfectly happy with the arrival of non-nationals. Instead, they're hoping to spread the ideas of their powerful internet-based services and promote their national brand, in order to coax others to use them from afar. And perhaps also to spread the idea to other countries that such a thing is possible. "We don't really like to speak to each other in person, so we went and created Skype and all these things," says Siret Schutting of the government project e-Estonia. "Stuff like this has to be a social right."

In the pine-lined IKEA-esque government showroom of Estonian innovation there is no one over 30 – it feels more like the offices of a volunteer-led arts organisation than an international showpiece – but foreign delegations visit every week in order to learn from the Estonian experience. Introducing the ID card, Schutting tells those visiting leaders, is a gradual process: "When you introduce an ID card, you get a lot of people asking, 'Why do I need that?' But then you add all of these services, and you can purchase a car from your living room, or vote from your living room or, when it's like minus 40 outside and you have a newborn baby, you probably don't want to go to the family office to name her: you do that online. Very small, pragmatic things."

Today, the fact that every interaction with, and within, the Estonian government happens digitally has had subtle social effects. For example, apart from only carrying two cards (driving licences, donor cards and the like have been subsumed into identity cards), Estonians have complete control over their personal data. The portal you can access with your identity card gives you a log of everyone who has accessed it. If you see something you do not like – a doctor other than your own looking at your medical records, for instance – you can click to report it to the data ombudsman. A civil servant then has to justify the intrusion.

Meanwhile, parliament is designed to be paperless: laws are even signed into effect with a digital signature on the president's tablet. And every draft law is available to the public to read online, at every stage of the legislative process; a complete breakdown of the substance and authorship of every change offers significant transparency over lobbying and potential corruption.

The culmination of these systems makes for awkward conversation with members of certain foreign governments. Strikingly young, dressed like a man who has borrowed a suit before visiting his in-laws for the first time, and sitting behind a chipped table that wouldn't make it into the caretaker's office in a western European capital, one

Estonian official, who didn't want to be named, reveals that e-Estonia has a list of foreign delegations they don't bother to have meetings with any more. These countries, he says, are so far behind in their thinking that time spent with them is too dull to bear. They just stare at us, he says.

Starting on April 27, 2009, Estonian web servers found themselves under constant attack for three weeks. Huge amounts of traffic, generated by virus-infected machines around the globe, overwhelmed the country's systems. More than 120 of these distributed denial of service attacks brought down sites across the country, including those belonging to the president, government ministries, newspapers, banks and local businesses. Although the systems behind the websites weren't damaged per se, they were unreachable for that time. It was a truly modern show of force, now considered one of the first major examples of a cyberattack on a nation.

Although it's never been proved, it has always been assumed in Estonia that the attack came from the Russian Federation – if not directly, then certainly with its support. The Russians, indeed, are commonly held by the Estonian-speaking majority to be up to no good. For most of the last 800 years, Estonians have been part of someone else's empire, and it's an ingrained belief that they're destined to become so again at some point: many are, post-Ukraine, deeply nervous of Vladimir Putin.

Many people in Tallinn say the same thing: we're next.

They're planning for it and the chief question is what will happen after an attack. The last time an annexed Estonia won independence, after years of rule from Moscow, the government was able to restore much of the country's land to a semblance of pre-Soviet ownership by consulting church records and other written documentation. Today, though, that documentation is entirely digital – and that makes all the difference.

"The point is that it's not only the data you need to back up," says Kotka, the Estonian tech entrepreneur turned government CIO. "If you look at what happens in Ukraine, for example, it's not a war, it's a hybrid war. So if you want to affect Estonia somehow, virally, make our ID card not work. Then we're in trouble. Banking: 40 per cent of people using e-banking are using their ID card for e-banking. Take those services down, and they can't access their money and they have to go physically to the bank... and since the banks have optimised according to the need, with 99 per cent of banking transactions happening electronically, they've closed their offices. So in a hybrid-war case, we need to back up services as well as data... so if the little green men" – he means the Russians – "decide to have their holiday here rather than in the Ukraine, just to be sure that the ID card works, we'll move it to the UK."

Or, indeed, any of his six planned "data embassies" around the world. At times of national emergency the plan is to be able to hit a switch and move the execution of the code that runs the systems behind the Estonian state to another server farm, one outside Estonia. An attack, even an invasion, can't shut down the local government because it doesn't need to

There is a list of foreign delegations that e-Estonia won't meet any more – their thinking is so backward that they are just too dull to bear being with



Left: Siret Schutting in the main hall of the e-Estonia showroom in Tallinn. Right: Taaki Kotka near his office

be local to still be a government. And even if the links are severed, eventually independence would be re-won and the state can be restored from a backup.

This can be applied not just to digital data and services; because everything from the Estonian parliament to its civil courts is paperless, they can be run from anywhere. In the old days, a government in exile would quickly lose legitimacy. Sheltering in another country, it would lack the infrastructure to do its work. But today an Estonian government in exile could just carry on. Fittingly, for a country that founded Skype, the judiciary could fly to the Caribbean, and it would mean nothing more than a series of particularly relaxed case hearings. They could be there today, if they wanted.

A state can go into hibernation. It could be backed up and turned off, a suitcase full of hard drives, only to boot back up when the time is right

It helps to clarify the differences between a nation, a state and a geographical country. These things are already a bit fuzzy, but in general a nation is a group of people within an area who perceive themselves as being the same type of person; a country is that geographical area itself; and a state is the set of political organisations that those people agree to adhere to. By disconnecting the silicon-based functions of the state from the actual soil-based country, Estonians are protecting their nation from fates that might befall their country.

But it's more than that. This is all software, and software can be easily, and perfectly, copied. So if the Estonians are successful in their efforts and they can build a digital state infrastructure that can be hosted anywhere, then there's

nothing to say they can't release the code and let another nation upload a new flag gif, change some of the names in the config file and boot themselves up their own version. It doesn't have to be an officially recognised state, either: fully realised, this brings down the barrier to entry to effective statehood for the more agile, more entrepreneurial separatist movements, budding caliphates or secessionist offshoots.

As the music industry discovered in the early part of the century, when something is digitised, it costs nothing to copy it. Perhaps the world of international relations is about to learn similar lessons. After all, if we can deterritorialise a state, could we perhaps state-ify a nation?

Gathering people of specific identities together is what the internet does. We're forever building nations online. There's British TV, a communal experience, but there's no British internet: we build our own experiences individually, through the people we hang out with online, regardless of geography. It's not proximity of distance but proximity of ideas that matters. Or perhaps proximity of time zone, as Cory Doctorow's *Eastern Standard Tribe* had it: shift workers allied to the people whose waking hours shared the same offset from GMT, no matter if that matched a London sunset to a Los Angeles sunrise. If we choose our communities by interest or culture – things we can choose – rather than by closeness, which is thrust upon us by birth,

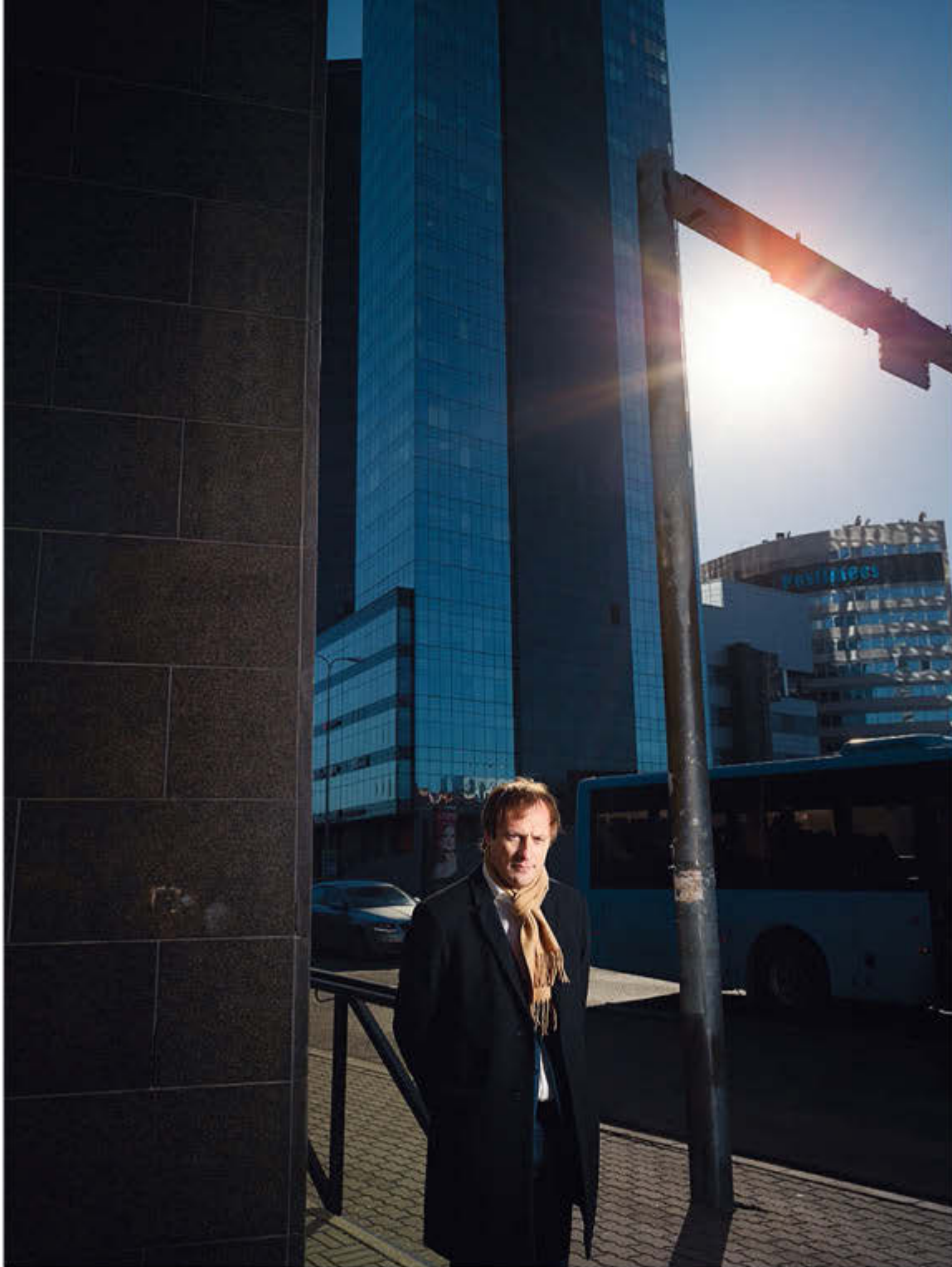
why not start choosing the state-level infrastructure we actually interact with on the basis of how well it works?

In 1996, one of the founders of the Electronic Frontier Foundation, John Perry Barlow, wrote a "A Declaration of the Independence of Cyberspace". A seminal text for its time, it says: "Cyberspace consists of transactions, relationships, and thought itself, arrayed like a standing wave in the web of our communications. Ours is a world that is both everywhere and nowhere, but it is not where bodies live."

When that declaration was made, it seemed outlandish because independence only went to actual nations which had all of the tools of a state. You had to have a parliament building before you could have a parliament. A state needed stuff to be of substance.

How to become e-Estonian

Since April 1, you can apply via an Estonian embassy. Take your passport or photo ID. You'll have your photo and fingerprints taken, fill in a form, then hand over €80 in cash (it's €50 if you're in Estonia).	Then comes the background check, when your documents are sent to Estonia. You may be asked why you want e-residency and whether you have any previous links with the country.	After about four weeks or so, you'll receive an email to let you know whether your application was successful. If it's a yes, you can go and pick up your identity card from the embassy.
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But today the Estonians are about to prove the opposite: that a state can go into hibernation. It could be backed up and turned off, reduced to a suitcase full of hard drives, only to boot back up again when the time is right.

Countries in waiting - Palestine, for example - could start to configure their own systems, building a whole state on a server, and run it all from the mobile browser. Insurgent states-within-states, like Hezbollah in Lebanon, could compete with the mainstream governments with better infrastructure, faster updates and more responsive bug fixing. Cities could institute entirely digital infrastructure and market themselves as providing a more convenient front end to their slower mother nation.

Until today, Estonia's infrastructure has only been available to Estonians. And although I may never go there again, I now have the right to use it too. According to the International Telecommunications Union, by 2020 80 per cent of the world's population will own a smartphone. Perhaps, soon after, where they choose to live and work and place their businesses will depend as much on the fertility of their country's digital infrastructure as its land. "Welcome to e-Estonia," says its website, "and enjoy a hassle-free life!" ■

Ben Hammersley is a contributing editor at WIRED and author of 64 Things You Need to Know Now for Then (Hodder & Stoughton)



The sand _____ and the fury
Computer chips. Glass. Concrete.
_____ The world is built on
sand. Mess with the mafias that
control it and you could pay with
your life _____

By Vince Beiser

Photography: Adam Ferguson



The killers rolled slowly down the narrow alley, three men on a single motorcycle. It was a little after 11am on July 31, 2013, the Sun beating down on the modest residential buildings lining a backstreet in the Indian farming village of Raipur Khadar. The smells of cooking spices, dust and sewage seasoned the air. The men stopped the bike in front of the orange door of a two-storey house. Two of them dismounted, eased open the unlocked door and slipped into the darkened bedroom on the other side. White handkerchiefs covered their lower faces. One of them carried a pistol.

Inside the bedroom Paleram Chauhan, a 52-year-old farmer, was napping after an early lunch. In the next room his wife and daughter-in-law were cleaning up while Paleram's son Ravindra played with his three-year-old nephew.

Gunshots suddenly thundered through the house. Preeti Chauhan, Paleram's daughter-in-law, rushed into the bedroom, Ravindra right behind her. Through the open door they saw the killers jump on their motorbike and roar away.

Paleram lay on his bed, blood bubbling out of his stomach, neck and head. "He tried to speak, but he couldn't," Preeti says,

her voice breaking. Ravindra borrowed a neighbour's car and rushed his father to a hospital, but it was too late. Paleram was dead on arrival.

Despite the killers' masks, the family had no doubts about who was behind the shooting. For a decade Paleram had been trying to get local authorities to shut down a powerful gang of criminals headquartered in Raipur Khadar that had for years been robbing the village of a coveted resource, one of the most sought-after commodities of the 21st century: sand.

That's right. Paleram Chauhan was killed over sand. And he wasn't the first, or the last.

Civilisation is built on sand – literally. It's been a critical component of construction and progress since ancient times. In the 15th century an Italian artisan figured out how to turn it into the transparent glass that made it possible to make the microscopes, telescopes and other technologies that helped drive the Renaissance's scientific revolution. Sand is an essential ingredient in detergents, cosmetics, toothpaste, solar panels, windows, silicon chips and buildings; every concrete structure around the world is basically sand and gravel glued together with cement.

Apart from water and air, humble sand is the natural resource most consumed by human beings. People use more than 36 billion tonnes of sand and gravel every year. But not just any sand will do: desert sand, shaped by wind rather than water, is too round to bind together for construction.

In fact, only sand worn by water is suitable. And the worldwide construction boom of recent years – all those megacities, from Lagos to Beijing – is devouring unprecedented quantities. Extracting sand is a £45-billion industry. In Dubai, huge land-reclamation projects and breakneck skyscraper construction have exhausted all nearby sources, so insatiable construction companies now

look elsewhere for their supply. Exporters in Australia are actually selling sand to Arabs.

As land quarries and riverbeds become tapped out, sand miners are turning to the seas, where ships vacuum huge amounts of the stuff from ocean floors. As you might expect, this all wreaks havoc on ecosystems. Sand mines in the US are blamed for beach erosion, water and air pollution and other ills from the California coast to Wisconsin's lakes. India's Supreme Court recently warned that riparian sand mining is undermining bridges and killing birds and fish all over the country. But regulations are scant and the will to enforce them is lacking.

Sand mining has erased two dozen Indonesian islands since 2005. The stuff of those former islands mostly ended up in Singapore, which needs titanic amounts to continue its programme of artificially adding territory. The city-state has created an extra 129km² in the past 40 years and is adding more, making it by far the world's largest sand importer. The environmental damage has been so extreme that Indonesia, Malaysia and Vietnam have all restricted or banned exports of sand to Singapore.

As a result, the global black market is booming. Half the sand used for construction in Morocco is estimated to be mined illegally; whole stretches of beach there are disappearing. One of Israel's most notorious gangsters got his start stealing sand from public beaches. Dozens of Malaysian officials were charged in 2010 with accepting bribes and sexual favours in exchange for allowing illegally mined sand to be smuggled into Singapore.

On Indonesia's island of Bali, far inland from the tourist beaches, WIRED visits a sand mine. It looks like Shangri-La after a meteor strike. In the middle of a beautiful valley, surrounded by jungle and rice paddies, is a six-hectare pit of exposed sand and rock. On its floor, men wearing shorts and flip-flops wield sledgehammers and shovels to push sand and gravel into clattering, smoke-



Above right:

Paleram Chauhan had been pressuring authorities to shut down a mining gang before he was murdered.

Right: Mining boats

work illegally on Thane Creek in Maharashtra. Divers scoop up sand and the crew hauls it to the surface

belching sorting machines. “Those who have permits to dig for sand have to pay for land restoration,” says Nyoman Sadra, a former member of the regional legislature. “But 70 per cent of the sand miners have no permits.” Even the companies with permits tend to spread bribes around so they can get away with digging wider or deeper pits.

But nowhere is the struggle for sand more violent than in India. Intense battles among and against sand mafias there have reportedly killed hundreds of people in recent years – with the victims including police officers, government officials and ordinary people such as Paleram Chauhan.

The area around Raipur Khadar used to be mostly agricultural – wheat and vegetables growing in the Yamuna River floodplain. But Delhi, less than an hour north, is encroaching fast. Driving down a new six-lane expressway, you pass construction site after construction site, new buildings sprouting skyward like the opening credits of *Game of Thrones* made real. Besides the

countless generic shopping malls, apartment blocks and office towers, a 2,000-hectare “Sports City”, including several stadiums and a Formula 1 racetrack, is under construction.

The building explosion got in gear about a decade ago – and so did the sand mafias. “There was some illegal sand mining before,” says Dushyant Nagar, head of a local farmers’ rights organisation, “but not on a scale where land was getting stolen or people were getting killed.”

The Chauhan family has lived in the area for centuries, Paleram’s son Aakash says. He’s slim, with wide brown eyes and receding black hair, wearing jeans, a grey

sweatshirt and flip-flops. We’re sitting on plastic chairs set on the bare concrete floor of the family’s living room, a few metres from where his father was killed.

The family owns about four hectares acres of land and shares some 90 hectares with the whole village – or used to. About ten years ago a group of local “musclemen”, as Aakash calls them, led by Rajpal Chauhan (no relation – it’s a common surname) and his three sons, seized control of the land. They stripped away its topsoil and started digging up the sand deposited by centuries of the Yamuna’s floods. To make matters worse, the dust kicked up by the operation stunted the growth of

crops, according to a complaint Paleram and other locals filed.

As a member of the village panchayat, or governing council, Paleram took the lead in a campaign to get the sand mine shut down. It should have been pretty straightforward. Sand mining is not permitted in the Raipur Khadar area at all, because it’s close to a bird sanctuary. And the government knew it was happening: in 2013 a federal fact-finding team found “rampant, unscientific and illegal mining” all over the district.

Nonetheless, Paleram and other villagers couldn’t get it stopped. They petitioned police, government officials and courts





Workers crush stone into sand at an illegal mine near Raipur Khadar



A miner works on an illicit sand-dredging operation near Mumbai

for years, but nothing happened. Conventional wisdom says that many local authorities accept bribes from the miners to stay out of their business – or are involved in the business themselves.

For those who don't take the carrot of a bribe, the mafias aren't shy about using a stick. "We do conduct raids on the illegal sand miners," says Navin Das, the official in charge of mining in the district. "But it's difficult because we get shot at." In the past three years, miners have killed at least three police officers and attacked many others, as well as officials, journalists and whistle-blowers.

According to court documents, Rajpal and his sons threatened

Paleram and his family, as well as other villagers. Aakash has known one of the sons, Sonu, since they were kids. "He used to be a decent guy," Aakash says. "But when he got into the sand-mining business and started making fast money, he developed a criminal mentality and started to become very aggressive." In the spring of 2013, police arrested Sonu and impounded some of his outfit's trucks. He was soon out on bail.

One morning Paleram rode his bicycle out to his fields, right next to the sand mine, and bumped into Sonu. "He said, 'It's your fault I was in jail,'" according to Aakash. "He told my father to drop the issue." Instead Paleram

complained to the police. A few days later, he was shot dead.

Sonu, his brother Kuldeep and Rajpal were arrested, but all of them are out on bail. Aakash sees them around sometimes. "It's a small village," he says.

The broad, murky Thane Creek, just outside Mumbai, is swarming with small wooden boats on a recent winter morning. Hundreds of them are anchored together in a ragged line stretching almost a kilometre. The banks are lined with mangroves, towered over by apartment blocks. There's a tang of salt in the air from the nearby Arabian Sea, mixed with diesel from the boats' engines.

Each boat carries a crew of six to ten men. One or two of them dive to the creek bottom, fill a bucket with sand and return to the surface. Then two others, standing barefoot on planks jutting from the boat, haul up the bucket with ropes.

Pralhad Mhatre, 41, dives about 200 times a day. He's worked here for 16 years. It pays nearly twice what the pullers get – about £10 a day. Mhatre wants his son and three daughters to go into another profession; he thinks the Thane will soon be mined out. "When I started, we only had to go down 20 feet," he says. "Now it's 40. We can only dive 50 feet. If it gets much lower, we'll be out of a job."

Rivers are excellent places to find sand. The stuff can be made by glaciers grinding up stones, by oceans degrading seashells, even by lava chilling and shattering upon contact with air. According to the Udden-Wentworth size scale, the most common geologic standard, sand is grains of any hard material between 0.0625mm and 2mm in diameter. But nearly 70 per cent of all sand is quartz. Time and the elements eat away at rock, grinding off grains. Rivers carry those grains, accumulating them in their beds, on their banks and where they meet the sea.

Quartz, a form of silicon dioxide, or silica, is one of the most common minerals on Earth. That's good, because it's really useful. Mixed with cement, water and gravel, it makes concrete. "Quartz is one of the hardest materials around, and the angularity of its grains makes them lock together well," says Michael Welland, a geologist and author of *Sand: The Never-Ending Story*. "And there's a hell of a lot of it."

In the wild, quartz comes mixed with other materials – iron oxides, feldspar, whatever prevails in the local geology. For commercial products you have to filter that out or start with a high silica content. The sand of France's Fontainebleau region, for instance, is upwards of 98 per cent pure silica. Europe's finest glassmakers have relied on it for centuries.

Corning operates the world's largest ophthalmic glass-

making centre in Fontainebleau; for lenses, the sand needs to be refined to 99.7 per cent silica. Electronics-grade silicon is refined to at least 99.999999999 per cent purity. As Welland writes, that's one atom of not-silicon among a billion silicon atoms.

The day after my trip to Thane Creek, Sumaira Abdulali, India's foremost campaigner against illegal sand mining, takes me to see a different kind of mine. The 54-year-old is a gentle and well-heeled member of the Mumbai bourgeoisie. For years she has been travelling to remote areas in a chauffeur-driven sedan, taking photographs of the sand mafias at work. In the process she's had her car windows smashed, been threatened, pelted with rocks, pursued at high speeds and punched hard enough to break a tooth.

Abdulali got involved when sand miners started tearing up a beach near Mumbai where her family has vacationed for generations. In 2004 she filed the first citizen-initiated court action against sand mining in India. It made the newspapers, which brought a flood of calls from others who wanted to stop their own local sand mafias. Abdulali has since helped dozens file court cases while keeping up a stream of complaints to local officials. "We don't want to halt development," she says. "But we want to put in accountability."

Over in the rural town of Mahad, sand miners once smashed up her car. Sand mining is banned here because of its proximity to a protected coastal zone. But in the jungled hills just outside town, we come to a grey-green river on which boats, in plain view, are sucking up sand from the bottom with diesel-powered pumps. The banks are dotted with piles of sand, which men are loading on to trucks.

Back on a main road, we find ourselves behind a convoy of three sand trucks. They rumble, past a police van parked on the shoulder. A couple of policemen idle nearby. Another is inside taking a nap. This is too much for Abdulali. We pull up alongside.

"Didn't you see those trucks carrying sand that just went past?" Abdulali asks an officer.

"We filed some cases this morning," answers the cop. "We're on our lunch break now."

Later I ask a local government official about this. "The police are hand in glove with the miners," says the official, who asks me not to name him. "When I call the police to escort me on a raid, they tip off the miners that we are coming." In the rare cases that are brought to court, no one has been convicted. "They always get off on some technicality."

Back in Raipur Khadar, after talking to Paleram Chauhan's family, Aakash agrees to show WIRED and our interpreter, Kumar Sambhav, the land the mafia has taken over. We'd rented a car in Delhi that morning, and Aakash directs our driver to the site. It's hard to miss: across the road from the village centre is an expanse of torn-up land pocked with craters up to six metres wide. Men are smashing rocks with hammers and loading trucks. They stop to stare at our car as we drive past. Aakash points out a heavy-set guy in jeans and a collared shirt: Sonu.

We get out to snap pictures of a huge crater. After a few minutes Aakash spots four men, three of them carrying shovels, striding purposefully toward us. "Sonu is coming," he mutters.

We start making our way back to the car, but we're too slow. "Motherfucker!" Sonu, now just a few metres away, barks at Aakash. "What are you doing here?"

Aakash keeps silent. Sambhav mumbles that we're tourists as we climb into the car. "I'll give you sisterfuckers a tour," Sonu says. He yanks open our driver's door and orders him out. The driver obeys. Aakash stays put.

"We're journalists," Sambhav says. "We're here to see how the mining is going." (This conversation was in Hindi; Sambhav translated for me afterwards.)

"Mining?" Sonu says. "We are not mining. What did you see?"

"We saw whatever we saw. And now we're leaving."

"No, you're not," Sonu says.



Thane Creek's sand will soon be mined out. 'If it gets much lower, we'll be out of a job'



A typology of sand

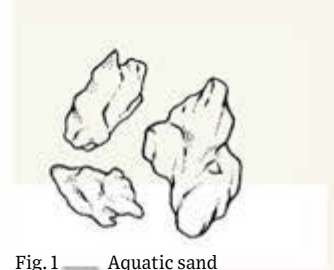


Fig. 1 Aquatic sand

Land quarries and riverbanks were once the main sources for sand. As these sources run out, dredgers turn to coastlines and the sea.

Unlike aggregates from rivers and streams, marine sand must be washed to remove salt, which would compromise building quality.

Sand for construction is largely quartz, though marine sand can also consist of coral, shells, lava, and other minerals.



Fig. 2 Desert sand

Weathered by wind, desert sand is too round and smooth for the grains to bind together in concrete.

Desert sand grains tend to be smaller and more uniform.

The exchange continues for a couple of tense minutes, until one of Sonu's goons points out the presence of a foreigner – me. This gives Sonu and his crew pause. Harming a westerner could mean trouble. We grab the chance to leave. Sonu, glaring, watches us go.

The case against Sonu and his relatives is grinding its way through India's courts. The outlook isn't great. "In our system you can buy anything – witnesses, police, administrative officials," a legal professional explains. "And those guys have a lot of money from the mining business."

Aakash keeps in touch with investigators and has tried to get India's National Human Rights

Commission to take an interest. His mother has wanted him to drop it since her other son, Ravindra – the main witness in the case – was found dead by some railroad tracks last year, run over by a train, apparently.

India is taking steps to get sand mining under control. The National Green Tribunal, a sort of court for environmental matters, hears citizen complaints about illegal sand mining. The government has enlisted India's space agency to provide satellite imagery to monitor river mining. Villagers have blocked roads to stop sand trucks, and almost every day some local or state official declares their determination to

combat sand mining. The magistrate of Raipur Khadar's district confiscated sand trucks and made arrests this year. But India has hundreds, if not thousands, of illegal sand-mining operations.

And the world's population is growing. People want housing, offices, factories, malls and roads. "The fundamental problem is the massive use of cement-based construction," says Ritwick Dutta, an Indian environmental lawyer. "That's why the sand mafia has become so huge." Economic development requires concrete and glass. It requires sand. ■

Vince Beiser is an award-winning journalist based in Los Angeles

Shifting sand: the price of construction

36 billion tonnes of sand and gravel used globally each year 596 million tonnes of construction sand and gravel shipped from the US in the first nine months of 2014 129km² of land created in Singapore since 1974 517 million tonnes of sand imported to Singapore since 1994 51 million tonnes of industrial sand and gravel used in the US in 2013 65 million tonnes of industrial sand and gravel used in the US in 2014 China has used more cement in the past three years than the US did in the entire 20th century 58 per cent of world cement production was used in China in 2012 2.3 million tonnes of silica sand exported from Australia in 2012-2013

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TILING THIS MONTH
Kirstie Little, William Lee, Chloe Glews and Courtney Stone of London-based design practice Giles Miller Studio

created our features opener this month. Little explains how they did it: "We created this 1.4m x 1.6m piece using our angular cast-zinc Harper tiles

in a variety of metallic finishes. The idea was to create an optical illusion, whereby the numbers are only revealed by reflected light." gilesmiller.com

REJECTED HEADLINES THIS MONTH
"Our writer went to Estonia, and all we got was this lousy e-residency permit"
"Snow jacket required"
"London: the hole story"
"Wimbledon's smart swingers"
"Head music"

PURCHASED THIS MONTH
£78 of bamboo, none of which was inserted under fingernails for missing deadlines. But there's always next issue...

REBOOTING BRITAIN PT. 2
The WIRED collective reveals what else needs fixing in the UK.
"All cyclists who sail through red lights should be punished with INSTANT DEATH."
"Bars that serve drinks in jam jars need to be burned to the ground."
"Arrest people who move too slowly due to looking at their phones."
"Anyone caught buying St Ivel Gold instead of real butter should be put on some sort of register."

"Scrap HS2 – we want a Hyperloop. London to Manchester in 23 minutes, easy."
"Tests to ensure people actually understand Bitcoin. You get a free bitcoin if you pass."

OVERHEARD AT WIRED THIS MONTH
"People have useful knowledge, you just have to squeeze them. Not physically."
"I had diamond earrings on and they scratched the screen on my iPhone – isn't that rubbish of Apple?"

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THE WIRED INDEX



70 METRES

The diameter of the moon found orbiting asteroid 2004 BL86 in January 2015

70 METRES

The diameter of the Nasa Deep Space Network antenna in California that took the radar images used to identify asteroid 2004 BL86's moon

Ninety

Percentage of patients who have reduced the size of their double chin using the experimental drug ATX-101, a series of between four and six facial injections that target fat, according to assertions from its California-based producers Kythera

Seventy-five

The percentage of participants in a study by Pennsylvania State University who, after being shown an image of a letter while being asked an unrelated question, could not correctly identify the letter after the image was removed

3KG

The amount of methamphetamine discovered in January when the battery-powered drone carrying it crashed on its way from Tijuana to San Diego

31.2%

Proportion of children born outside marriage in England and Wales in 1992

40.6%

Proportion in 2002

47.5%

Proportion in 2012



30 million

Volume of cubic metres of water a sub-glacial lake in Greenland contained before the pressure of excess water caused it to drain, according to researchers at Ohio State University, who discovered the crater it left behind

54

Number of fine-avoiding companies and citizens named and shamed as "dishonest" on a public electronic billboard in Hunan, China, in January 2015

28 million RMB (£3m)

The largest amount of money owed to the Chinese courts by one of those named and shamed

£8.5 million

Estimated value of metal extracted from sewer waste produced by one million people over a year, according to a study led by Arizona State University professor Paul Westerhoff. The 13 most lucrative elements had a combined value of £183 per tonne of sludge

1 IN 2,000

Proportion of tweets about marijuana, according to a study at the Washington University School of Medicine

SEVENTY SEVEN

Percentage of those tweets that are pro-marijuana, based on a 7,000-tweet sample taken by the researchers

FIVE PER CENT

Proportion of those tweets classified as anti-marijuana, based on the same 7,000-tweet sample



¥7,000

Starting room rate (£39) for one night at the humanoid robot-staffed Henn-na hotel at the Huis Ten Bosch theme park in Nagasaki, Japan

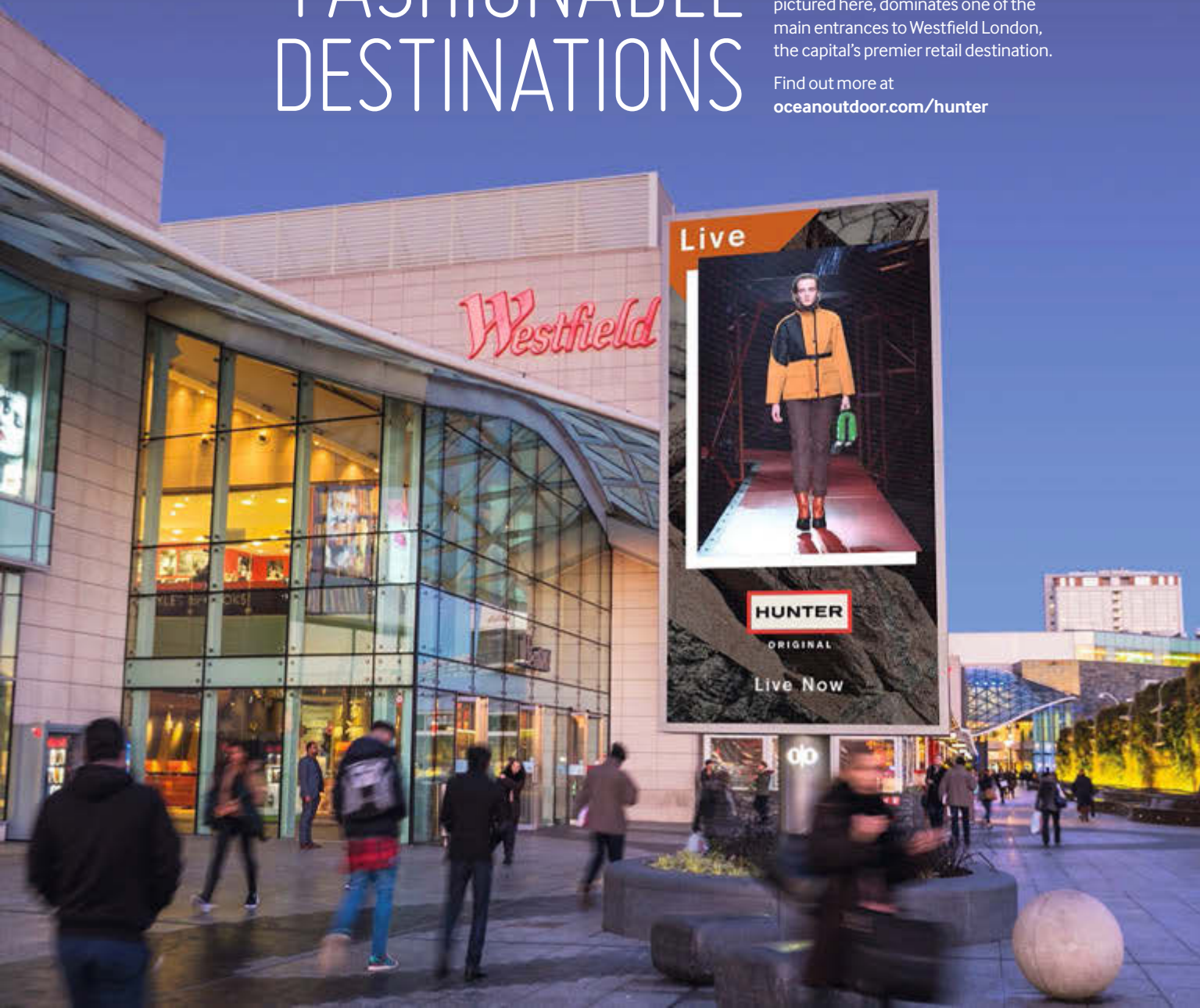


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On the cover Swatch Sistem51
£108 swatch.com

TIMELESS STYLE

BRAUN BN0211 LADIES' CLASSIC SLIM

One of four new pieces for 2015, the BN0211 embodies Braun's Dieter Rams-defined "less but better" design philosophy. The 32mm stainless-steel case is just 6.5mm thick, while the three-hand quartz movement is topped with scratch-resistant mineral glass. But it's the Milanese bracelet that sets off this elegantly restrained timepiece. *£150 braun-clocks.com*

THEY ONLY COME OUT AT NIGHT

How effective are wristwatches once the Sun goes down? WIRED puts four shining examples under the spotlight

3. OMEGA SEAMASTER DIVER 300 M CO-AXIAL 41 MM

A diving watch that can be worn with a business suit, Omega's 41mm Seamaster is beautifully restrained, right down to the size of the screw-down crown and matching helium escape-valve at ten o'clock. Under the crystal, Omega uses the same blue Super-LumiNova paint as Tudor, with contrasting green pigment for the minute hand and the dive bezel's zero marker. The indices are easy to read up close, but took only 90 minutes to dim noticeably. **7/10** £2,770 omega-watches.com

- Clearly detailed markings
- Quick to fade

1. BALL ENGINEER II MAGNETO S

A sleek anti-magnetic watch, the Magneto S features an open automatic movement at the rear. Rotating the knurled bezel on the front activates an iris-like magnetic shield that shuts over the sapphire window, protecting it against up to 80,000A/m (amperes per metre). As for illumination, its sharp-edged tritium tubes are raised above the dial to

provide clear-cut luminescence, with orange lume on the hour, minute and second hands and 12 o'clock marker, and white lume on the remaining hour indices. Although not the brightest on test, it was still possible to read the time from over three metres away. **9/10** £2,510 ballwatch.com

- Precise, easy-to-read indices
- Stiff strap

2. LUMINOX SCOTT CASSELL DEEP DIVE SPECIAL EDITION A.1526

A collaboration between the Californian ruggedised timepiece brand and a special-ops diver turned environmentalist, this hefty cuff-buster is, despite its 17.05mm-thick PVD casing and safety clasp, surprisingly comfortable on the wrist. The biggest disappointment with this special edition 44mm-diameter watch is that compared to its considerable surface area, the tritium light tubes are

frustratingly small in size and number. So, although it aced our longevity test – its makers promise a “constant glow for up to 25 years in any light condition” – the Luminox proved far harder to decipher in the gloom than it should have done. **6/10** £1,595 luminox.com

- Long-lasting light source
- Ineffective glowing markers

LUMINOUS

HOW WE TESTED

WIRED selected four leading diving watches and left each timepiece in direct daylight for 12 hours. We then gauged their efficacy in complete darkness via three separate trials: their initial brightness at close range; readability at distance; and the time it took for the watch lume to visibly fade. Additional marks were also awarded for design, comfort and ease of use.

BRIGHTNESS IN USE

The brightness and visibility of watches at close range when worn on tester's wrist.

● ● ● ● ● — Brightest

TIMED ILLUMINATION

Degree of visible luminosity over time (at half-hourly intervals)

22.30: start
23.00: no change
23.30: no change
00.00: Omega slightly dimmer
00.30: Omega same; Tudor slightly dimmer
01.00: Omega and Tudor considerably dimmer

DISTANCE/VISIBILITY

Omega **160cm**
 Luminox **210cm**
 Tudor **265cm**
 Ball **320cm**

4. TUDOR PELAGOS 25500TN

Like the rugged Luminox, Tudor's famous all-titanium diving watch will happily operate at 500 metres below sea level, although its night-light credentials come courtesy of the strontium aluminate-based Super-LumiNova pigment, as opposed to radioluminescent tritium-filled glass vials. The Pelagos was the only watch we tested which

applies luminous tech to the full extent of its hour, minute and second hands, plus the five-minute indicators and dive bezel increments. The result is a watch that positively beams in the darkness, although its intensity noticeably began to wane after two hours. **8/10** £2,840 tudorwatch.com

- Brightest watch on test
- Intensity quickly fades



1 2
3 4





INSIDE STORY

SWATCH AND THE AUTOMATED ROBOTIC REVOLUTION

How the Swiss brand creates its new Sistem51 – an automatic for the people

There's no neat answer to the question of how long it takes to make a mechanical watch movement. Ask Patek Philippe and it'll tell you it took five years to develop its record-breaking Calibre 89 pocket watch – most of which was spent figuring out how to get 33 complications into the movement – plus another four years to manufacture it. Cartier says the movement inside its Rondo de Cartier Grande Complication, launched in January this year, takes 15 weeks to manufacture, ten weeks to decorate and five weeks to assemble.

These are extremes, of course. But even when you take a “tractor” movement, such as the Swiss watch industry workhorse, the ETA 2892, there's still plenty of time involved. Components

have to be machined to very fine tolerances; then, as required, they have to be finished, decorated, assembled by hand, tested, cased up, then tested again... Time waits for no man, unless he's Swiss. Which is why it's a head-turner when a Swiss brand openly admits it's making mechanical watch movements – manufactured, assembled and decorated – with almost no human intervention.

That brand is Swatch, still as joyfully disruptive as it was when it burst on to the scene more than 30 years ago, and the movement is the one inside Sistem51, the only watch in the world made entirely (forgetting the strap) by an automated system. Theoretically, the facility could crank out six watches a minute, but in reality, every finished movement passes through a caravan of machines over a slightly longer period of time.

Sistem51 is made at Boncourt in Switzerland's north-western tip. By WIRED's calculations, its new manufacturing facility pumps out (a verb you'd struggle to use justly for any other Swiss watch brand) 4,000 watches a day (that's almost three finished watches a minute), around a million a year, using a network of 400 machines spread across a vast production floor that covers 15,000m².

These are big numbers by Swiss watch industry standards. Rolex, Swiss watchmaking's giant, is believed to produce a similar number of watches annually, but across its entire range; TAG Heuer half that; and Patek Philippe only 55,000. Granted, the comparison is irrelevant when you consider the quality of the end products, but when you remember the Federation of the Swiss Watch Industry reported 8.1 million mechanical watches were exported from Switzerland last year, it at least creates some context.

Sistem51 was first mooted in 2011. At that point, Swatch was two years shy of its 30th anniversary and looking for something to market the date around. Swatch was launched in 1983 and built its reputation on the popularity of its cheerful fashion watches and their colourful plastic cases and straps (by 2006, the firm was celebrating its 333-millionth Swatch). But what's often forgotten is that the quartz movement inside these was a technical marvel. It had just 51 parts, a little over half the number required by most quartz movements, yet proved accurate and reliable.

The idea for the brand's 30th anniversary was to repeat the feat, only with an automatic (or self-winding) mechanical watch. Humdrum mechanical watch movements have around 130 components – Swatch's would have just 51, its lucky number, meaning the brand would have to scale another watchmaking mountain.

The company began a rapid process of conceptualisation, industrialisation and human resource management, and two short years later announced Sistem51 to a gobsmacked audience at the Baselworld spring watch fair. The week leading up to Christmas that year – week 51, naturally – the watch was introduced in Switzerland, then internationally through 2014.

Like the original Swatch, the Sistem51 has broad appeal. On the one hand, it's fashionable and fun, with peppy designs and a democratising price point – in the UK it retails for £108 – making the cachet of a Swiss Made mechanical watch accessible to the masses.

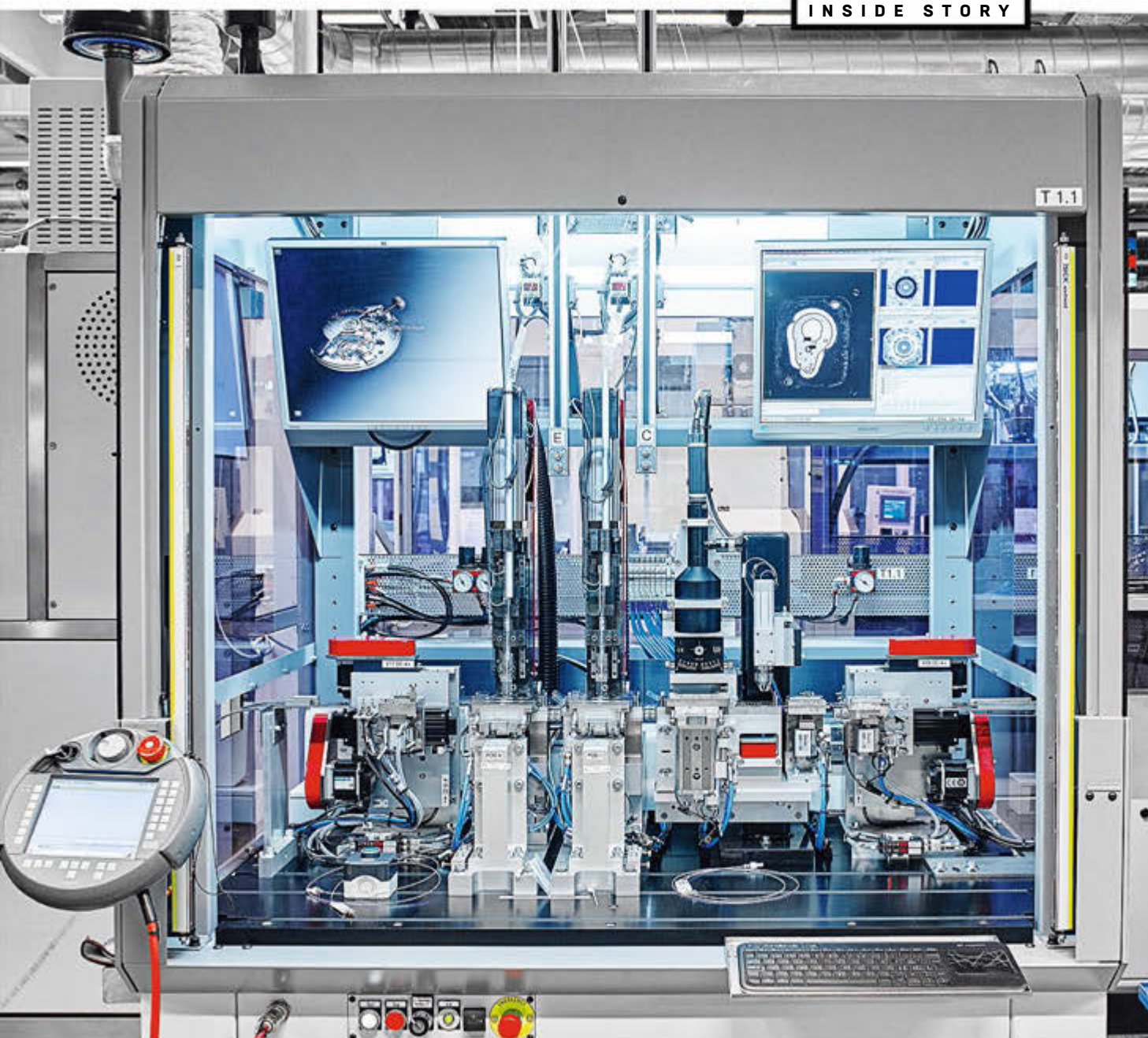


1. MAIN FLOOR MOUNTING LINE

Swatch's Boncourt facility covers 15,000m² and houses more than 400 machines, some of which have as many as 12 modules. These ones are mounting the jewels on which the gears sit.

2. SISTEM51 ASSEMBLY

Swatch's Sistem51 assembly line is fully automated. Inside each machine a robotic arm performs a task – here, the bezels are glued into place on the watch case. The glue is set fast using computer controlled lasers.



But on the other, it's watch-nerd crystal meth. In the weeks after it went on sale, Sistem51 popped up on a raft of websites better known for getting rather worked up over balance cocks and Breguet overcoils. Their photo essays detailing the crude journey through the watch's hermetically sealed case and into its soldered movement generated huge interest – watch-industry mouthpiece *Europa Star*'s Sistem51 dissection is the fifth most-popular piece it has ever posted.

Some were outraged by its plastic escapement and pallet fork (made from a material Swatch has kept secret); but most, including *Europa Star*, goggled at the achievement of creating an automatic movement with

**ON ONE HAND,
THE SWATCH
IS FUN, WITH
ITS PEPPY
DESIGNS.
ON THE OTHER,
IT'S CRYSTAL
METH FOR
WATCH NERDS**

only 51 parts that has a 90-hour power reserve (the norm is around 40 hours). Its claimed accuracy of ± 7 seconds a day makes it accurate enough to qualify for chronometer status – an honour used as marketing leverage by Rolex, Omega and Breitling.

More than that, there was bewilderment that Swatch had designed Sistem51 so it couldn't be serviced, claiming instead that it will never need maintenance, although it'll be



3. JEWEL MOUNTING

The screens at this station allow humans to monitor the placement of synthetic jewels on the Sistem51 movement. These help the gears to run frictionlessly, so enabling accurate timekeeping.



4. ASSEMBLY LINE CHECKING

Production of Sistem51 may be fully automated, but the system is overseen by 500 people working across three shifts over a 24-hour period.

5. PRINTING MACHINE

Once the Sistem51 movement is fully assembled, it's decorated using a digital printer. The Sistem51 is the only mechanical movement in the world decorated after assembly.

some time before the theory can be backed up with results. On paper then, Sistem51 is a bona fide watchmaking revolution. So too is the process behind it. Boncourt's 400 machines – some of which have 12 modules – work 24 hours a day, up to six days a week, churning out parts made to minute tolerances, assembling Sistem51's five modules, fixing them to the mainplate, and then decorating the finished movement in a range of colours using a digital printer, making it the only movement in the world to be decorated *after* assembly.

Little explains its staggering efficiency better than the mainplate (think chassis) manufacturing process. Normally (again), this requires more than 50 machines, but Swatch's engineers have pared it back to just five. First of those is a stamping machine that applies 16 tonnes of pressure to a thin strip of ARCAP (an anti-corrosive, anti-magnetic, nickel-based alloy), pressing out the basic shape. The strip is then fed into a sequence of three machines, each 20 metres long, that drill the base architecture into the mainplate. The fifth is a "garnishing" machine that adds tiny, frictionless jewels and axes.

Then there's the assembly room, where row upon row of machines filled with peripatetic robotic arms whirl methodically like a chorus of mime artists, gluing and soldering the watch together. Each of these has a job to do – placing a movement in a case, positioning the dial, testing the winding system, regulating the timing mechanism, attaching the hands, gluing the domed plastic cover and so on – and each uses computer monitored lasers to guarantee every operation is carried out with the necessary precision. If any measurement is slightly out, work ceases on that watch, and it passes through the system like a corpse on its way to the morgue. Incredibly, though, this is only half the story. Next spring, Swatch will open a second factory over the road, a carbon copy of its current premises – complete with 1,000 roof-mounted solar panels and a rainwater purification system – that will double capacity. By the end of 2016, Swatch could be making two million Sistem51s a year, equivalent to more than a fifth of Switzerland's mechanical watch exports.

Sistem51 marks the industrialisation of Swiss watchmaking. A little over 30 years after it first turned the Swiss watch industry on its head, Swatch just might be sparking a second revolution.

A

ll too often when a watch brand brings out something “new”, it turns out to be nothing more than a blue dial on an old model, or a re-skinned update of an already familiar line.

Not so with Brevia. The young brand, founded by fashion entrepreneur Vincent Dupontreué, burst on to the scene two years ago with a watch that, thanks to a miniature

aneroid barometric capsule, can forecast the weather. Last year’s Génie 02 used the same air-pressure measurements to deliver a pretty accurate reading of altitude on the dial.

After that start, one could have been forgiven for wondering whether the bottle that had given rise to the first two Génies was exhausted – but apparently not. This year’s Génie 03 has the brand breaking new ground once again.

Continuing on the theme of atmospheric measurements, the Génie 03 is the only watch to feature a mechanical anemometer. The penny-sized upper-right sector of the dial is in fact a spring-

loaded module that, at the press of a button, pops out from the dial, standing 6mm proud of the watch and exposing a tiny three-cup anemometer, free to spin in whatever wind you can hold it up in. The watch is intended less as a meteorological tool than a (slightly) more practical speedometer; skiing enthusiast Dupontreué sees it as something you might deploy *en piste*, and as such the readings taken by the anemometer translate on to a kph scale atop the module. Fine-tuning the anemometer to

Wind readings are calibrated from 20kph to 200kph

work correctly took Brevia a year, and a patent has been granted for its creation.

Another piece of ingenuity at work here is the water- and shock-proofing of the movement – whether the speedo is open or closed – and of the watch as a whole when the speedo is down. Given the vulnerabilities of Swiss watch movements to outside influences, this is no box-ticking sales exercise, but real expertise at work. It should be yet more impressive that the timekeeping side of the watch – as well as the speedometer – is made entirely in-house by Brevia.

The Génie 03 also represents a welcome move for the brand, price-wise. Granted, £39,000 is nobody’s small change, but it compares well with £123,000 for the brand’s debut model. If this is the way the wind is blowing at Brevia, long may it last. brevia-watch.com

PHOTOGRAPHY: ANDY BARTER. WORDS: CHRIS HALL

CLOSE-UP

012

BREVA GÉNIE 03 ANEMOMETER

A watch that can measure wind speed completes Brevia’s hat-trick of innovation





Orville Wright taking first flight with brother Wilbur running alongside at Kitty Hawk, North Carolina, 17 December 1903.

Image credit: WSU/planepix.com



A FEW SELECT PEOPLE HAVE BEEN GIVEN PART OF THE
WORLD'S FIRST AIRCRAFT. PRESIDENTS, ASTRONAUTS
AND ANYONE WITH A BREMONT WRIGHT FLYER.

The Bremont Wright Flyer is a tribute to the Wright Brothers' famous aircraft. It's remarkable to look at. But what makes it even more remarkable is that it features actual material from that very first aircraft. The watch also features another first: our first proprietary movement, the BWC/01. The Wright Flyer is available now in a limited edition. But it's unlikely to be available for long.

BREMONT
CHRONOMETERS

**PURE
AND
SIMPLE**

1 / 4



CLEAR CALENDAR

**GEORG JENSEN
KOPPEL GRAND
DATE ANNUAL**

Timepieces with annual calendars are usually coupled with complicated dial layouts, but the new Koppel Grand Date Annual Calendar is sleek and reductionist. A stainless-steel case houses the Dubois Dépraz calibre 14950, a self-winding movement with a 42-hour power reserve. The date is displayed through a double-chamber aperture, while a small seconds dial is below-right of the super-slim hands. To the left of this dial is a semi-circular window displaying a mixture of Arabic numerals and dots to represent the 12 months of the year. The result is a piece that is stark and contemporary. £3,500 georgjensen.com



PHOTOGRAPHY: ANDY BARTER. WORDS: JEREMY WHITE

CLEAN CLASSIC

**JUNGHANS
MAX BILL
DAMEN RED**

Swiss designer Max Bill, who studied at the Bauhaus school in Dessau, Germany, often cited the significance of beauty in his designs. Junghans approached Bill in 1956 to design a set of watches and clocks and, in 1961, it released a series of wristwatches combining clean lines, simple geometry and a unique type – instantly creating timepiece classics. This latest 32.7mm-diameter Max Bill Damen in bright red (also available in blue) references colours that the designer used regularly in his work. The red tone is incorporated into both the leather/satin strap and the hour indicators, subtly adding to the purist dial. £430 junghans.de



TASTEFUL TIME

**NOMOS
TANGENTE
AUTOMATIK**

Nomos's first ever wristwatch was the Tangente, designed in the clean style of the Deutscher Werkbund movement, which set the visual tone for the rest of its timepieces to follow. The exterior remains clean and clear, but inside, the Tangente now comes with an in-house-developed automatic movement. The 3.2mm-thick DUW 3001 has a 42-hour power reserve and bidirectional automatic winding. With such a slender movement, the Tangente Automatik comes in at a mere 6.9mm, only 0.3mm taller than the hand-wound version – and WIRED also approves of the modest case diameter of 35.5mm. £2,390 nomos-glashuette.com

FETISH

**Digital extra!**

Download the
WIRED app
to read about
an additional
timepiece

SILVER MACHINE

**ZENITH
ELITE 6150
42MM**

Beautifully designed and furnished with high-performance in-house movements, the Elite line is Zenith's slimmer, dressier range. Its 42mm stainless-steel Elite 6150 boasts an ultra-clean silver-toned dial and rhodium-plated hands for a distinctly retro feel – yet inside is Zenith's latest movement, which gives the piece its name. A 3.92mm-thick automatic, the 6150 beats at 4Hz for more than four days before needing to be wound. Meanwhile, the case has a thickness of just 9.45mm, and its tapered lugs make this piece appear even more slender. A black alligator strap seals the understated deal. £5,600 zenith-watches.com



SWISS + MADE



ESSENTIAL GEAR.

ANU Chronograph Series No. 4241; 45mm, IP black plated stainless steel case and caseback, with crown protection and blockable pushers, unidirectional ratcheting bezel, antireflective sapphire crystal, multi jewel Swiss quartz movement with 8+ year lithium battery, water resistant to 200 meters, signature PU strap and black PVD brushed steel loops, and Luminox self-powered illumination. Swiss Made.

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WHERE THE SMART MONEY IS GOING

Now Apple has legitimised the market, Swiss brands are cautiously exploring the world of smartwatches

A

nd so it began last September, when Apple's senior vice president of design, Jony Ive, is supposed to have pronounced that Swiss watchmakers are dead (only in more colourful language) – such was his confidence in the power of the Apple Watch to disrupt an industry reportedly worth CHF 38 billion (£25bn). Irrespective of the legitimacy of his claim, a line had been drawn and Jean-Claude Biver, president of the LVMH group's global watchmaking portfolio, diplomatically retorted that the Apple Watch "looks like it was designed by a student in their first trimester".

Yet just three months later, Tag Heuer – an LVMH marque – announced its intention to enter the smartwatch market. "Smartwatches represent a challenge to the Swiss watch industry that is comparable to the appearance of quartz technology," said Guy Sémon, general manager of LVMH, in a Reuters interview. "We cannot ignore this tsunami."

This perceived threat to the established order is not without merit: although Switzerland exported 28.6 million watches in 2014, Apple took one million pre-orders for its Watch in a single day in April, according to research body Slice Intelligence. The question is whether it is feasible to maintain the accuracy of a mechanical Swiss watch when it is packed with electronic sensors.

Billing itself as the first Swiss-made smartwatch, Mondaine's Helvetica No 1 Smart (*main picture*) shows promise for an industry that, although no stranger to innovation, has not always been adept at moving with the times. Analogue in appearance, its sub-dial at the six o'clock position is tasked with displaying life-logging data. It's powered by MotionX, the same Bluetooth-enabled OS found in Jawbone's UP3 fitness band and



Tag Heuer
Carrera Heuer-01



Breitling
B55 Connected



Montblanc
e-Strap

SMARTWATCHES

forthcoming Swiss smartwatches from Frédérique Constant and Alpina. Montblanc's solution directly addresses the issue of obsolescence: if a fine watch is built for future generations, how do you go about future-proofing its smart technology? By integrating it into a removable strap. The Urban Speed e-Strap is a fire-resistant leather band featuring a touchscreen display. A similar approach has been adopted by IWC for its Connect, a button-shaped device due to be embedded in its watchbands. Although Tag Heuer is yet to convert its early statement of intent into something tangible, at this year's Baselworld fair it announced a partnership with Google and Intel to launch an upgradeable connected watch sometime in 2015 – its partially-skeletonised Carrera Heuer-01 is believed to form the basis of its design. Breitling, meanwhile, has gone beyond proof of concept with its smartphone-enabled chronograph, the B55 Connected. Driven by its own SuperQuartz movement, the watch comprises an analogue face and dual LCDs, with an app wirelessly backing up its data.

Last – but not least – is Swatch, which has form in the smartwatch arena: ten years ago it launched the Paparazzi, a connected digital timepiece that used Microsoft's MSN Direct service to display everything from football transfer news to FTSE shares. Its subscription-only format doomed it to failure, but it underlined the brand's foresight. This year, Swatch will launch a new model that can handle communication, mobile payments and Windows- and Android-compatible apps – yet such connected features will apparently be kept to a minimum. "People are trying to put too much in there that a phone can already do," said CEO Nick Hayek in March. "Why do I have to bring another display?" Smart thinking.

BREMONT BOEING MODEL 247 TI-GMT**Price** £4,995**bremont.com****Size** 43mm**Movement**

Modified BE-54AE automatic chronometer

Unique feature

Trip-Tick case construction; Bremont Boeing skeletonised rotor; organic polymer strap

GROUND FLIGHTS OF FANCY

Models for aspiring pilots are ascetic and durable

By Henry Farrar-Hockley

The pioneering aeroplane *Solar Impulse 2* finally took to the skies over Abu Dhabi in March, as it set out to complete the first circumnavigation of the globe – powered only by the Sun. To see out the 35,000km journey, some 17,000 solar cells (each with a thickness of just 135 microns) have been built into the plane's 71.9-metre wingspan to run its four 17.5 CV electric motors. The cockpit is rather less high-tech: the unpressurised single-seater capsule has room for a life raft, basic rations and six oxygen bottles.

It is perhaps fitting that 2015 is also turning out to be a big year for pilot watches. WIRED's first recommendation for any aspiring aeronauts comes from British aviators-turned-watchmakers Nick and Giles English, whose Bremont Model 247 Ti-GMT is inspired by the Boeing Company's progressive twin-engine 247 airliner from the 30s. Their intentionally ascetic chronograph utilises Ti 6-4 – a strengthened titanium used in airframes and engine components.

Bearing the same checklist of desirable features as an aviator's timepiece – durability, legibility and a chronograph function for timing



BREITLING CHRONOLINER

Price £5,560**breitling.com****Size** 46mm**Movement**

Breitling Calibre 24

Unique feature

Third time zone on bidirectional ceramic bezel

flights – the Breitling Chronoliner's contrasting colour scheme makes it simple to pick out the white 12-hour, 30-minute, and 60-second “totalisers” against its black face and ceramic bezel. (Its second time zone indicator, meanwhile, is marked out by Breitling's signature red arrow.)

Given that Patek Philippe's ties to air travel are rather less well-documented, its new pilot watch marks a major departure for the haute watchmaking marque. The Calatrava Pilot Travel Time focuses on enhancing the execution of dual-time complications, hence its day/night indicators for local and home time, and twin pushers at the eight- and ten-hour positions for easily adding and subtracting hours to synchronise with your next destination.



PATEK PHILIPPE 5524G-001 CALATRAVA PILOT TRAVEL TIME

Price CHF 42,000**patek.com****Size** 42mm**Movement**

Calibre CH 324 S C FUS

Unique feature

Lockable pushers for adjusting time





**HAMILTON
JAZZMASTER
VIEWMATIC
SKELETON
LADY AUTO**
Price £1,000
hamiltonwatch.com
Size 42mm
Movement Calibre
H-20-S
Unique feature
Interlocked
"H" engraving;
skeletonised rotors

Women don't do watches with complications," seems to have been the message coming out of Switzerland for many years. Reasons include not being able to set them – the counter-argument being how many men have you known who can actually program their GMTs – or not wanting something too complex, with the approved wisdom being that the only complication a woman can cope with is a moonphase.

Patek Philippe has been quietly ignoring the rest of Switzerland since 2009, when it launched its Ladies First collection with a column-wheel controlled CH 29-535 PS chronograph calibre. It was not only the first time Patek had put it in a women's watch, it was the first time it had ever put it in a watch, regardless of gender. It's taken five years for other watchmaking marques to play catch-up, but they have – and with some impressive results.

IWC led the charge in 2014, when it put a dual-time in one of its new Portofino Midsize watches, which caters to the growing demand for this sort of complication from career women who need to know what the time is where their families are. Seiko picked up on this when it made its Astron, which can instantly find the time in any of the 39 zones thanks to satellite triangulation – and smaller and white is an obvious attempt to please its female customer base. The trend for useful complications in women's watches continued in January, when Vacheron Constantin came to the Salon International de la Haute Horlogerie with its Harmony collection, which featured the brand's first-ever women's chronograph. Although this year's Baselworld didn't up the ante much, what it did reveal was that more brands were also taking women's watches seriously enough to try out crafts beyond stone-setting. Hamilton, for one, chose to skeletonise one of its women's watches – another first in the brand's history.

We may be a long way from women's timepieces having equal sway with men's, but if this year's progress is anything to go by, there may be parity in the world of watches long before the world of business.

**IWC PORTOFINO
MIDSIZE
AUTOMATIC DAY
& NIGHT**
Price £50,550
iwc.com
Size 37mm
Movement
Calibre 35700
Unique feature
Steel case with
66 diamonds;
mother of
pearl dial with
12 diamonds



EQUALITY GETS A BIG HAND

Women's watches now have a wider range of functions
By Laura McCreddie



**SEIKO ASTRON GPS
SOLAR LIMITED
EDITION**
Price £2,995
seiko-astron.com
Size 45mm
Movement
GPS-adjusted 8X82
Unique feature
Limited edition of
1,000; diamond-set
indices on the dial;
crocodile strap

Remember that flashback to Bruce Willis's character's childhood in *Pulp Fiction*? Christopher Walken's Captain Koons coaxes a young Butch Coolidge from his TV cartoons by presenting him with a gold watch – one that had belonged to generations of Coolidge men, which Koons “wore up his ass” during his time in a PoW camp.

Other than sincerely hoping that the captain had since given it a thorough clean and service, many of us noticed that Quentin Tarantino's props team had done well, as it's a genuine first world war “trench” watch, complete with soldered wire-loop strap attachments for its migration from the pocket to the wrist through crude modification. The theatre of war has remained an incubator for all manner of horological development, from luminescence (Panerai) to the rotating bezel (Blancpain).

“For deployed ops, ruggedness and functionality are king,” an RAF flight sergeant tells WIRED. “A lot of the commando or infantry's wristwear – from the lowest ranks right through to the SAS – tends to be Traser.”

CASIO G-SHOCK GPW-1000RAF

Price £850

g-shock.co.uk

Size 56mm

Movement

Quartz with
hybrid display

**Unique
feature** Hybrid
GPS/atomic
timekeeping

A little-known offshoot of a Swiss microtech firm, the military-issue Traser H3 uses proprietary tritium gas tubes (the same ones used by Luminor) to illuminate its dial markings at a constant glow of 6,000 nanocandela for over 20 years. By comparison, standard Luminor depletes to 400 nanocandela after an hour of darkness. Alternatively, you'll find Casio's G-Shock on the wrists of many other soldiers. Its legendary toughness encompasses resistance to (deep breath) electricity, gravity, low temperature, vibration, water ingress and – of course – shock. There's also a new RAF collaboration, the GPW-1000RAF, which brings together GPS signal and atomic-clock radio-wave timekeeping for the first time.

However, at operational bonus time, top of the list is the Omega Seamaster, according to our sergeant.

The new Seamaster 300 seems most appropriate, as despite its rheumy-eyed allusions to the 1957 diving watch, all of Omega's latest technology is to be found within – from the Master Co-Axial movement, resistant to up to 15,000 gauss of magnetism (handy for hands-on

engineers) to the wetsuit-adjustable ratchet clasp. A far cry from the trenches of Ypres, but as suitable a suppository as ever.

PHOTOGRAPHY: ANDY BARTER

WRIST-TO-WRIST COMBAT

Tough timepieces that have earned their stripes
By Alex Doak



OMEGA SEAMASTER 300

Price £4,170

omegawatches.com

Size 41mm

Movement

Calibre 8400

Unique feature

Antimagnetic
co-axial
movement

TRASER H3 P6504 BLACK STORM PRO

Price £350

traser.com

Size 43mm

Movement

Ronda 715 Swiss
quartz

Unique feature
Green tritium gas
illumination

RAYMOND WEIL

GENEVE



CELEBRATING 100 YEARS OF **SINATRA™**

RAYMOND WEIL proudly presents the *maestro* Frank Sinatra Limited Edition in homage to the ultimate music icon. This unique timepiece was created in partnership with Frank Sinatra Enterprises as part of the "Sinatra 100" Centennial Celebration and is limited to 1,212 pieces in reference to the artist's birth date. Happy Birthday Frank!

Join the celebration #RWSinatra100

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cufflinks from WILLIAM & SON



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EXPERT CHOICES

**PATEK PHILIPPE
MULTI-SCALE
CHRONOGRAPH****Price** CHF 55,000*patek.com***Size** 40mm**Movement**

Calibre CH

28-520

Unique feature

White gold

edition of 400



It's an old adage that you can tell the health of the economy by the number of cranes scattered across a city's horizon. These days, a similarly accurate judgement could be made by looking at the timepieces worn by the city's elite – high-end wristwatches have become

the prosperity yardstick for the modern age, despite having roots that go back centuries. Aware of the culture of horological one-upmanship now prevalent in boardrooms across the Square Mile and beyond, and never known to miss a trick, watch brands have upped their game. With every new year comes a raft of high-tariff, low-volume tickers aimed at people who have become millionaires during their own lunchtime.

Some of these are brash, garish tributes to ostentation, but not all. Patek Philippe is still undisputed king of the understated city-slicker watch. The Genevan house makes a reported 55,000 watches a year, but could sell many times that number, meaning waiting lists for pieces such as its 175th anniversary Multi-Scale Chronograph can stretch into the horological hinterland for even the highest rollers. Incorporating tachymeter, pulsometer and telemeter scales, it is available in editions of 400 for each of its yellow, white and rose gold versions (CHF 55,000). Scarce enough, but the platinum edition (CHF 78,000), with just 100 pieces, only makes matter worse.

Also excruciatingly limited is Vacheron Constantin's Harmony Chronograph (£53,450), a piece housing the venerable maison's debut in-house chronograph calibre. Only 260 of these cushion-shaped rose-gold beauties will come to market to celebrate the brand's 260th anniversary year. Each one is hand-wound and features a natty monopusher chronograph function, which starts, stops and resets through a single push-piece set into the crown.

Thank goodness therefore for IWC's unlimited Portugieser Annual Calendar (CHF 34,000), the first timepiece in the 75-year history of the company's evergreen watch family with a full date indication that only needs adjusting once a year, in February.

TIME TO SPARE, MILLIONAIRE?

Exclusive editions that are worth the wait
By Robin Swithinbank

**VACHERON
CONSTANTIN
HARMONY
CHRONOGRAPH****Price** £53,450*vacheron-constantin.com***Size** 42mm**Movement**

Calibre 3500

Unique feature

Monopusher

**IWC
PORTUGIESER
ANNUAL
CALENDAR****Price** CHF 34,000*iwc.com***Size** 44.2mm**Movement**

Calibre 52850

Unique feature

Rotor with 18k gold medallion



SETTINGS FOR THE HIGH SEAS

It's aye-aye captain to these sturdy pieces for sailors

By Chris Hall

ROLEX YACHT-MASTER II 116655

Price £4,995

rolex.com

Size 40mm

Movement

Calibre 3135

Power reserve

48 hours

Unique feature

Solid-block 18k

Everose-

gold case; black

Cerachrom

bezel; Oysterflex

bracelet



**PANERAI
LUMINOR 1950
REGATTA 3
DAYS CHRONO
FLYBACK**

Price €13,900

panerai.com

Size 47mm

Movement

Calibre P.9100/R

Unique feature

Glucydur balance

**MAURICE
LACROIX PONTOS
S REGATTA**

Price £5,380

mauricelacroix.

com

Size 45mm

Movement

ML162 automatic

Unique feature

"Forged carbon"
watchcase

Unless you're an America's Cup helmsman, with Oracle's millions at your back and a carbon-fibre yacht laden with technology, there's still a case (albeit a romantically tinged one) to be made for the use of a sturdy sailing watch – perhaps with a countdown timer for regatta racing. Here are three capable timepieces fit for any skipper's wrist.

Built from titanium and rubber with a wetsuit-friendly expandable strap, Panerai's Luminor 1950 Regatta 3 Days Chrono Flyback (the diving brand's first foray into above-the-waves watchmaking) features a countdown timer adjustable in duration from one to 15 minutes. When the timer's up, the chronograph automatically starts timing the race length if left ticking. As an added bonus, the outer dial features a tachymeter scale calibrated in knots – sure-footed sailors can hence calculate their

race speed between two points. Rolex's key launch for 2015 – its flagship, if you will – is the Yacht-Master. It's a time-only watch in Rolex's patented Everose gold; if that sounds rather unsuitable for the sea, consider this: it's Rolex's first watch to use what appears at first sight to be a rubber strap. It's not rubber though; this being Rolex, it insists on the title "high performance elastomer". But it is clever: within the rubber-like material are dozens of thin, laterally-set metal blades that make it tougher and more durable than anything else like it on the market. It also boasts a "longitudinal cushion system" – two thin non-rubber flanges that ensure a super-stable fit on the wrist. Just the ticket for carefree seafaring.

If the Rolex is still a bit too showy, the Maurice Lacroix Pontos S Regatta provides a more understated alternative. It's the latest addition to the Pontos S range – the pieces that proved the brand was about more than square-wheeled curios and baroque dress watches. It ticks down from ten minutes and has the clearest countdown display around. For top marks in both lightness and strength, the case is cast from forged carbon. Made by moulding carbon-fibre pellets together to give an irregular yet extremely durable composite, it also provides a gorgeous marbled finish.

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Swiss
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Time for life—with two limited edition timepieces in support of Doctors Without Borders/Médecins Sans Frontières. Each watch raises £100 for the Nobel Peace Prize winning humanitarian organization. And still these handcrafted mechanical watches with the red 12 cost the same as the classic Tangente models from NOMOS Glashütte. Help now, wear forever.

£100 from every product sold is paid to Médecins Sans Frontières UK, a UK registered charity no. 1026588. NOMOS retailers helping to help include CS Bedford, CW Sellors, Catherine Jones, Fraser Hart, Hamilton & Inches, Mappin & Webb, Orro, Perfect Timing, Stewart's Watches, Stuart Thexton, Watches of Switzerland. Find these and other authorized NOMOS retailers at nomos-watches.com, or order online at nomos-store.com

AUDEMARS PIGUET ROYAL OAK CONCEPT RD#1

This watch takes the gong for its loud yet tuneful chime system

A raised section on the 44mm case amplifies the sound



029

Audemars Piguet's Royal Oak Concept RD#1 is changing the way watchmakers perceive, create and amplify the sound of their minute repeaters. It chimes the time louder and prouder than anything before: a full 10dB louder, even with a waterproof titanium case and when worn on the wrist. So much so that when Audemars' head of product management, Christian Lasalmonie, activated the RD#1's striking mechanism during January's Salon International de la Haute Horlogerie (SIHH) trade fair, the slack-jawed journalists sat at the back

of the lecture hall could tell the time, to the minute.

Audemars Piguet is no stranger to this aspect of watchmaking. Founded in 1875, as many as nine of the company's first 12 models of watch were equipped with pioneering French horologist Abraham-Louis Breguet's newly developed striking system, whereby tiny hammers struck finely tuned steel "gongs" coiled inside the case, instead of hitting the case itself.

This element of the minute repeater has barely changed with the RD#1, but pretty much everything else has – the result of an eight-year audio-research initiative.

Crafted in collaboration with the nearby École Polytechnique Fédérale de Lausanne; a pitch-perfect musician from the Conservatoire de Musique de Genève; a sound engineer; and a local artisan who crafts stringed instruments, it's not simply an academic exercise but a chiming watch that rewrites sound definition for timepieces.

"We particularly liked the sound of a rectangular Gübelin wristwatch, made in Lucerne in 1924 – its clarity and beauty, rather than its volume *per se*," says Audemars Piguet CEO François-Henry Bennahmias. "So we removed it from the museum collection and studied it intensely."

The most revolutionary development was "tuning"

the alloy gongs. Attached at just one end, a minute repeater's gong vibrates in singular "partials" without harmony. Therefore, the most important thing is not the note itself, but the relationship between its two gongs' partials. For the RD#1, the partials have been redefined, with a perfect interval of two notes, or a "major third" to be musical.

It's a cliché, but the effect really does have to be heard to be believed – which should be possible soon, once the technology trickles down to AP's core collection. Meanwhile, try to imagine a staccato Chinese wind-chime... but without the wind. audemarspiguet.com

Digital extra!

Download the WIRED app to read an extended profile of the RD#1



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WATCH REPORT 2015

WIRED discovers what's new in horology at Baselworld and SIHH

This year, the watchmaking industry's two principle fairs – Baselworld and Salon International de la Haute Horlogerie (SIHH) – have once again proven to be showcases for remarkable innovation, from the use of radical new materials and mechanisms to watches with unconventional design influences, ranging from stringed instruments to iconic automobiles.



1. SLIM D'HERMÈS 32MM LADIES'

This everyday dress watch is set apart from the rest by an ultra-thin Vaucher movement, which was four years in the making, and a bespoke typeface for its hour markers devised by graphic designer Philippe Apeloig.

From £2,000
hermes.com



2. IWC INGENIEUR AUTOMATIC EDITION 'AMG GT'

Presenting the first watch to be crafted from solid boron carbide, which is the toughest ceramic, bar none. Limited to 25 pieces, the GT was commissioned to commemorate IWC and Mercedes-AMG's ten-year partnership.

£17,750 iwc.com



4. TUDOR NORTH FLAG

Modelled on the scientific instruments that were worn by the British North Greenland Expedition of the 50s, this steel and ceramic hybrid contains Tudor's first in-house COSC-certified calibre.

From £2,430
tudorwatch.com



5. HYT H3

Unlike previous iterations of HYT's H range, the H3's 62mm x 41mm rectangular PVD-coated titanium and platinum case houses a linear fluidic indication rather than a circular one, here marking time in six-hour intervals.

£209,000
hytwatch.com



6. A. LANGE & SÖHNE ZEITWERK MINUTE REPEATER

Utilising the same technology from its €2.4-million Grand Complication, A. Lange & Söhne's decimal repeater chimes at hour, minute and ten-minute intervals via its 771-component movement.

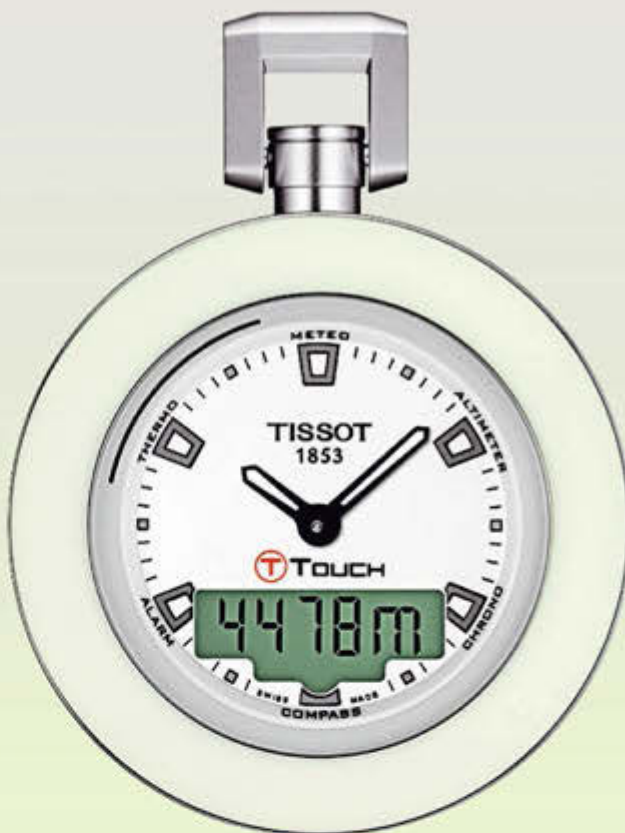
£440,000
alange-soehne.com



7. CASIO MUDMASTER GWG-1000-1A3

Combining the best of G-Shock's RANGEMAN and MUDMAN models from its MASTER of G line, this solar-powered, radio-synchronised watch handles inhospitable environments of all types, including down to a chilly -10°C.

£500 g-shock.co.uk



3. TISSOT POCKET TOUCH

With its Swiss quartz movement and sapphire crystal touchscreen, this pioneering pocket-watch includes a

thermometer, altimeter, compass, chronograph, barometer and calendar. **£620**
tissotshop.com

SHOW REPORT



**8. BREGUET
TRADITION 7707
INDÉPENDENT
CHRONOGRAPH**

The offset Guilloché dial, which features hours and minutes, leaves a decent amount of space to showcase this watch's twin balances: one for timekeeping, the other for the chronograph.

£57,000 breguet.com



**9. RALPH LAUREN
RL AUTOMOTIVE
SKELETON 45MM**

A 45mm Amboyne burl bezel encases the skeletonised Calibre RL1967.

It's the very same wood type that's employed in the steering wheel of Lauren's own coveted 1938 Bugatti 57SC Atlantic Coupé. **£23,000**

ralphlauren.com



**10. CHANEL J12
SKELETON FLYING
TOURBILLON**

The 77-component flying tourbillon beneath Renaud et Papi's partially open-worked caliber is overlaid by a diamond-set shooting star that constantly rotates on its axis. It was created exclusively for Chanel, of course. **£poa** chanel.com

The movement can be observed from both front and back



**11. CARTIER
ROTONDE
DE CARTIER
ASTROTOURBILLON
SKELETON**

Unlike conventional tourbillons, this one rotates around the perimeter of the watch dial, rather than spinning on its own axis. The 47mm, 18k white gold case is fully skeletonised.

£135,000 cartier.com



**12. SEIKO
MARINEMASTER
PROFESSIONAL
1000M DIVER'S**

This titanium and ceramic diver has a two-layer case construction that's impermeable to helium. Its enhanced Lumibrite indicators ensure it remains legible up to 60 per cent longer than previous versions.

£2,750 seiko.co.uk

**13. OMEGA SPEEDMASTER
WHITE SIDE OF THE MOON**

A bit of all white, Omega's latest take on its iconic lunar timepiece features a gleaming white ceramic dial and

bezel insert. The matching white case is zirconium oxide, and the strap is alligator. **£8,200**

omegawatches.com



SHOW REPORT



**14. RAYMOND WEIL
NABUCCO CELLO
TOURBILLON**

This piece uses the signature "sound hole" design of a cello to craft two PVD-coated bridges, each securing both the tourbillon complication and the mainspring with its 105-hour power reserve. **CHF 39,000**

raymond-weil.com



**15. RADO
HYPERCHROME
AUTOMATIC XL**

This 42mm timepiece unusually comprises a single monobloc case that is hewn from plasma ceramic – a material that's exceptionally resistant to scratches – and uses a fade-proof gun-metal finish. **£2,500** rado.com



**16. BLANCPAIN
L-EVOLUTION
TOURBILLON
CARROUSEL**

With its modernist aesthetic, this watch combines two time-regulating complications – the tourbillon and carrousel – into one, using a trick differential wound through the same crown. **£258,700** blancpain.com



**17. HUBLOT BIG
BANG UNICO FULL
MAGIC GOLD**

Proclaimed to be the world's only scratch-resistant gold wristwatch, thanks to Hublot's proprietary alloy of ceramic and 18-karat gold. This imbues the case with an indentation resistance of almost 1,000 on the Vickers hardness scale. **€30,600** hublot.com

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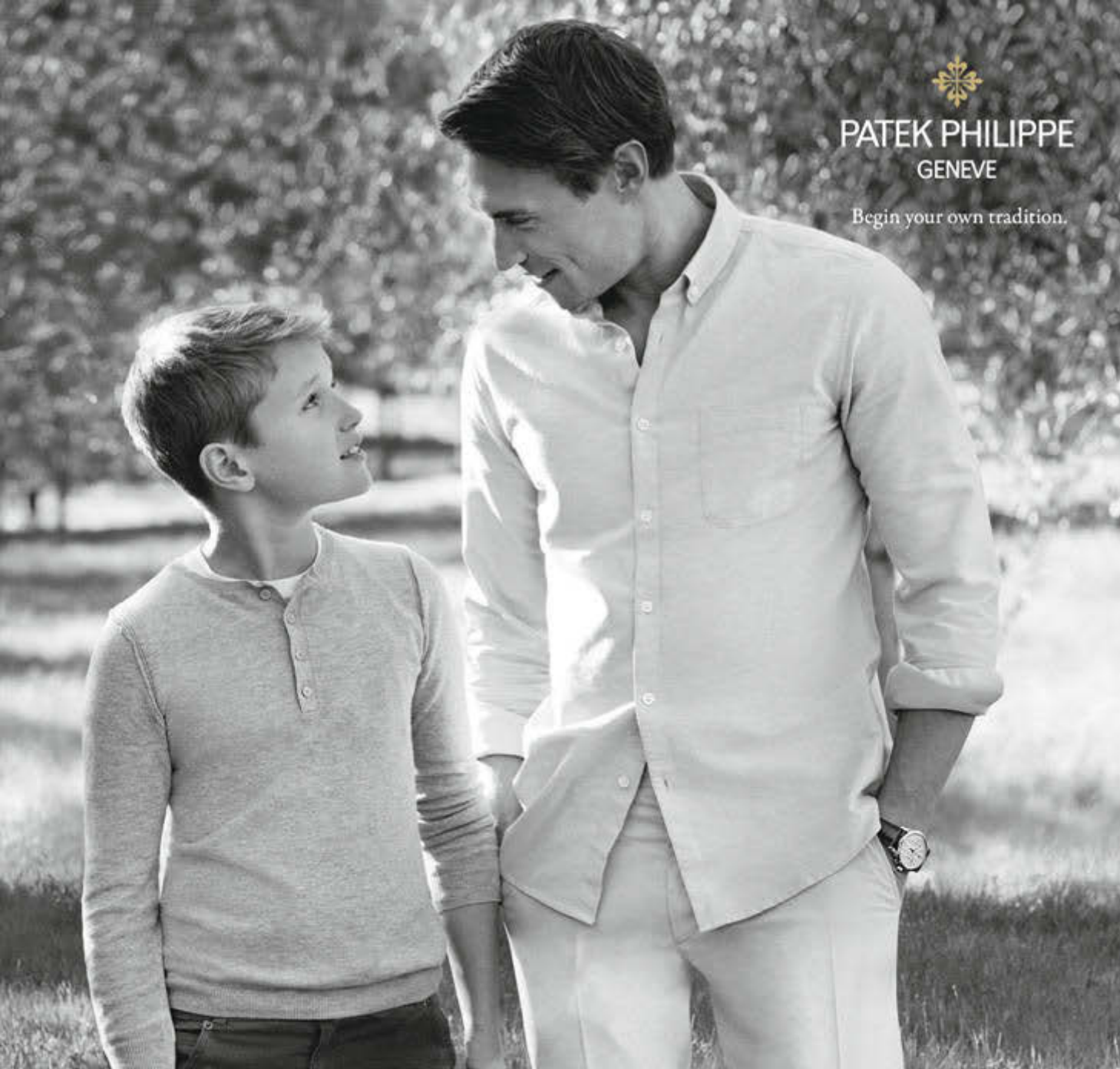


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